2016 Middle Peninsula All- Hazards Mitigation Plan Update

Public Comment Period June 29, 2015 to July 28, 2015

Dear Middle Peninsula Citizen:

The Middle Peninsula Planning District Commission (MPPDC), in collaboration with local officials from Essex, Gloucester, King & Queen, King William, Mathews, and Middlesex Counties and the Towns of Tappahannock, West Point, and Urbanna is updating the 2010 Middle Peninsula All-Hazards Mitigation Plan. The Plan evaluates all hazards that may affect the region and proposes cost-effective mitigation strategies to lessen the adverse impacts of future hazardous events.

As part of Plan development, public comment and feedback is required. This Plan currently includes 4 Sections for review, including the Introduction, Community Profiles, Hazard Identification, as well as Risk Analysis Assessment. The remaining chapters will become available upon completion of the Plan.

Please submit written comments to Ms. Jackie Rickards, Regional Projects Planner II, at jrickards@mppdc.com or mail comments to:

Middle Peninsula Planning District Commission
PO Box 286
125 Bowden Avenue
Saluda, VA 23149

Also the draft All Hazards Mitigation Plan is available for review at local libraries including:

Mathews Memorial Library
251 Main Street
Mathews, VA 23109
(804) 725-5747

Essex Public Library
117 N. Church Lane
Tappahannock, VA 22560
(804) 443-4945

Urbanna Branch Public Library
150 Grace Street
Urbanna, VA 23175
(804) 758-5717

Gloucester County Main Library
6920 Main Street
Gloucester, VA 23061
(804) 693-2998

King & Queen Branch Library
396 Newtown Road
St. Stephen's Church, VA 23148
(804) 769-1623

Upper King William Branch Library
694-J Sharon Rd
Sharon Office Park
King William, VA 23086
(804) 769-3731

Pamunkey Regional Library – West Point Branch Library
721 Main Street
West Point, VA 23181
(804) 843-3244

Finally, MPPDC staff will host two public meetings. Meetings are scheduled for Wednesday**, July 29, 2015 at** 5-7pm in the King & Queen Branch Library Conference Room (396 Newtown Road St. Stephen's

Church, VA 23148 (804) 769-1623) and on **Thursday, July 30, 2015 at** 5-7pm in the Middle Peninsula Planning District Commission Boardroom (125 Bowden Street Saluda, VA 23149 (804) 758-2311).

Thank you for taking the time to reviewing this document!!

Sincerely,

Jackie Rickards
Phone: (215) 264-6451
Email: jrickards@mppdc.com

Section 1: Introduction

The Disaster Mitigation Act of 2000 (DMA 2K) is a key component of the Federal government's commitment to reduce damages to private and public property through mitigation actions. This legislation established the Pre-Disaster Mitigation (PDM) Program and created requirements for the Post-Disaster Hazard Mitigation Grant Program (HMGP). This key piece of federal legislation is known as Public Law 106-390.

DMA 2K requires local governments to develop and submit mitigation plans to qualify for Hazard Mitigation Assistance (HMA) funds. The Act requires the plan to demonstrate "a jurisdiction's commitment to reduce risk from natural hazards, serving as a guide for decision makers as they commit resources to reducing the effects of natural hazards." Upon completion, the final plan must be approved by the Virginia Department of Emergency Management (VDEM) as well as the Federal Emergency Management Agency (FEMA), and then adopted by each participating jurisdiction.

Therefore to meet such requirements the Middle Peninsula Planning District Commission (MPPDC) guided the development of a Regional Natural Hazard Mitigation Plans and Plan updates according to the requirements of DMA 2K. All nine (9) Middle Peninsula localities, including Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex Counties and the Towns of Tappahannock, Urbanna, and West Point, participated in the plan's development and amendments. The region's first plan was adopted by local jurisdictions in 2006, the second plan in 2010, and this third plan was adopted by local jurisdictions in ______ and by FEMA in ______ *(dates to be determined).*

Hazard Mitigation is defined as any sustained action taken to reduce or eliminate long-term risk to human life or property from hazards. This plan follows DMA 2K planning requirements and associated guidance documents for developing Natural Hazards Mitigation Plans. The guidance sets forth a four-step mitigation planning process that includes the following (FEMA, 2015):

The plan also utilizes the elements outlined in FEMA's Crosswalk Reference Document for Review and Submission of Local Mitigation Plans as published by FEMA in January, 2012 in accordance with 44 CFR 78.5.

Since the adoption of the Middle Peninsula Natural Hazards Mitigation Plan (MPNHMP) in 2006, the nine (9) Middle Peninsula jurisdictions jointly participated in Revision #1 of the plan by developing detailed flood mitigation strategies to address the region's most critical natural hazards (ie. flooding from severe storms). Revision #2 was a review and update of the remaining non-flood related natural hazards facing the Middle Peninsula region. To remain compliant with DMA 2K the plan must be reviewed and adopted every five years. Therefore as the 2010 Hazards Mitigation Plan expires in December 2015, MPPDC staff drafted a grant proposal to the Virginia Department of Emergency Management (VDEM) to update the 2010 All Hazards Mitigation Plan. Upon receipt of funding, Middle Peninsula localities signed a memorandum of understanding committing local funds and personnel to this endeavor.

Section 2: The Planning Process – Public Involvement and Community Partners

This Section is still under development.

SECTION 3: Community Profile of Middle Peninsula Localities

To update the 2011 All-Hazards Mitigation Plan, a planning process was utilized that involved Middle Peninsula localities as well as the general public. Thus through extensive dialog amongst localities as well as input from the general public community profile(s) of the Middle Peninsula as it relates to the nature of critical, moderately-critical, and non-critical hazards were created.

Description of Area

The Middle Peninsula region encompasses six (6) counties and three (3) towns including Essex, Gloucester, King and Queen, King William, Mathews, and Middlesex Counties as well as the Towns of Tappahannock, Urbanna, and West Point (Figure 1). According to the 2010 Census, the total population of the Middle Peninsula is 90,826.

The Middle Peninsula is located on the western shore of the Chesapeake Bay, bound to the north by the Rappahannock River and to the south by the York River. The region is located in the Virginia coastal plain with a relatively flat topography. The southeastern-most portions of the region are at sea level, while elevation rises to approximately 200 feet above sea level moving in a northwesterly direction.

Based on the regions low topography and its 1200+ mile of coastline, the Middle Peninsula has an abundance of its many waterways-broad rivers, meandering creeks, wide bays and tidal marshes – all of which contribute to the region's susceptibility to floods and coastal storms. Additionally with a high water table the lower elevations of the Middle Peninsula makes it difficult for land to drain and thus exacerbating flooding from summer thunderstorms, hurricanes, nor'easters, as well as rising seas. Tidal surges associated with these severe storms often compound the flooding within this region.

While the Middle Peninsula region remains largely rural, it lies in close proximity to the metropolitan areas of Hampton Roads, Richmond and the Fredericksburg-Northern Virginia Metropolitan Areas. Suburban growth from these urban areas is spreading into the Middle Peninsula, affecting the region's resource-based industries and traditional rural lifestyle. For instance the region's traditional land use patterns can best be described as having:

- A predominantly rural character with large, scattered farms and forested tracts;
- A number of closely-knit, small communities surrounded by working farms and forests;
- Small scale commercial fishing communities along the lower reaches of the watersheds;
- Three small towns which provide a focal point for commercial, industrial and residential development at a modest scale; and
- Government operation centers which provide another focal point of local activity in the region.

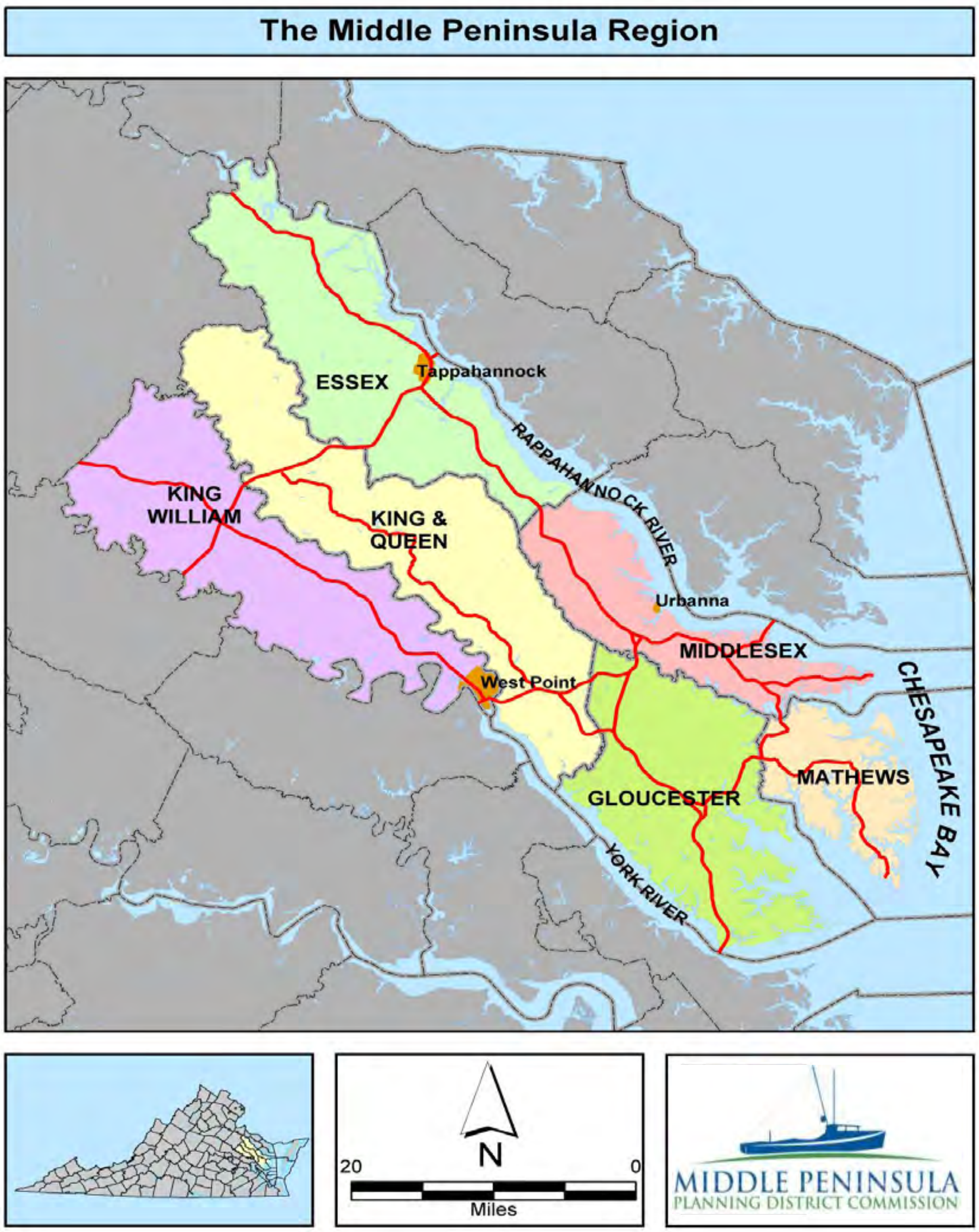
However the last 20 to 30 years, the region has seen a slight shift to:

- Growing sectors in tourism, retiree housing and related retiree services;
- Large forested tracts are converting from woodlands to residential development
- Waterfront communities transitioning from commercial fisheries with a reduced level of fisheries to an increasing number of marinas and residential developments; and

- Commercial development being located along Route 33 in Middlesex, Route 360 in King William, and Route 17 in southern Gloucester County between the Court House and the Coleman Bridge.

In summary, changes in land uses that concentrate development along the region's numerous waterfront areas poses the greatest risk for hazard prevention and mitigation activities – particularly in the low-lying southeastern areas of Mathews, Gloucester and Middlesex Counties.

Figure 1:



Essex County

Essex County is predominantly a rural county located at the northern end of the Middle Peninsula. It is bound on the north and east by the Rappahannock River, on the south by Middlesex County and on the west by Caroline and King and Queen Counties. The County comprises of approximately 261 square miles (Essex County Comprehensive Plan, 2003). Residential developments exist as small rural communities along the Rappahannock River or along the primary and many secondary roads. With a history of slow/gradual growth and strong land use control regulations, the County has remained mostly rural.

The 2010 Census figures showed the population to be 11,151 people, an increase of 1,162 (11.63%) over the 2000 census. The population has 5,274 men and 5,877 women and is comprised of 6,370 whites, 4,247 African Americans, and 534 people of other races. The population aged somewhat during the period from 2000 to 2010 with a modest reduction in school age population. These trends suggest that County programs may require redirection to meeting the specific needs (i.e. health care, transportation) of an older population. A low to moderate trend in growth in the County's population is expected to continue into the future.

Town of Tappahannock

Tappahannock is an incorporated town located along the shores of the Rappahannock River in the east-central portion of Essex County. The Town of Tappahannock is both the employment and population center of the County. Occupying less than three square miles of land, Tappahannock features an active waterfront, a historic downtown, residential subdivisions, schools and other public facilities, an old airport and industrial center, a business corridor, and extensive wetland areas. Tappahannock serves as the county seat for Essex County.

The 2010 Census showed the population to be 2,375 people, an increase of 307 (14.8%) from the 2000 Census. The population has 975 men and 1,400 women and is comprised of 1,076 whites, 1,128 African Americans, and 171 people of other races.

Gloucester County

The 2010 Census showed the Gloucester County population to be 36,858 people, an increase of 2,078 (5.97%) from the 2000 Census. The population has 18,239 men and 18,619 women, comprised of 32,149 whites, 3,197 African Americans, and 1,512 people of other races. A moderate trend in growth is expected to continue in the future (Virginia Employment Commission, 2013).

The County's proximity to urban centers to the south, and the northwestward migration of suburban development from the greater Hampton Roads/Newport News area has transformed portions of the County into a suburban landscape. This is most pronounced at the southern reaches of the County in and between the Historic Court House village and the Gloucester Point-Hayes areas. Residents from the Hampton Roads area and other areas of the urban crescent are lured to the County by the promise of lower taxes, lower housing costs, rural character, and relative freedom from the congestion evident in metropolitan areas. This has created increased traffic volumes on the limited collector roads not designed for such heavy use within the county. Commuters, travelers and trucks from the Middle Peninsula and points north use Route 17 as an alternative to interstate 64 to get to the Peninsula, Southside and the Outer Banks. Route 17 is the primary route through Gloucester and is also the heart of Gloucester's Development District where public water and sewer are available and where the county has expressed a desire to see continued economic development along this corridor. The need for alternative routes and connection to take local traffic off of Route 17 to reduce congestion is one of the goals expressed in the adopted Comprehensive Plan and the proposed update to the plan.

Despite the urban/suburban character of the County's Development District, the majority of the County remains relatively rural with low density development and active farm and timberlands. Much of the eastern portion of the County, east of Route 17 and South of Route 3/14 is characterized by low lying lands, low to moderate density housing and waterfront homes and communities. North of the Court House is very similar to other localities on the Middle Peninsula with a mixture of low and moderate density residential development and large tracts of farms and forests. Route 33, which runs along the northern portion of the County, provides convenient access from the interstate to upper Gloucester and Mathews County.

King and Queen County

King and Queen County is located in the north-central portion of the Middle Peninsula and is bounded on the west by the York and Mattaponi Rivers which separate King and Queen from King William and New Kent Counties. The Dragon Swamp separates King and Queen County from Essex, Middlesex and Gloucester Counties on the east. Often called the "shoestring county", King and Queen County is about 65 miles long and less than 10 miles wide. Farming and logging continue to be the mainstays to the local economy.

King and Queen County is the least populous county of the Middle Peninsula and one of the most rural counties in Virginia today. In 1990, the population density was only 20 people per square mile. Nearly three-fourths of the County's 318.1 square miles of land area is timberland. Over the past four decades, King and Queen County has experienced slow, but steady population growth. In 2010 the population density was 22 people per square mile.

The 2010 Census showed the King and Queen County population to be 6,945 people, an increase of 315 (4.8%) over the 2000 census. The population has 3,454 men and 3,491 women and is comprised of 4,663 whites, 1,975 African Americans, and 307 people of other races. A moderate trend in population growth is expected to continue in the future and the overall population distribution appears to be experiencing a gradual shift to the upper and lower ends of the County where transportation routes to jobs and retail markets are most favorable.

King William County

Located approximately 20 miles northeast of the City of Richmond, King William County is rapidly growing into a bedroom community of the metro-Richmond area. Much of the county's 286 square miles are made up of gently rolling farmland and scenic timberland located between the Pamunkey and Mattaponi Rivers. Farming and logging continue to be the mainstays of the local economy. King William is home to the only Native American Indian Reservations in the Commonwealth and to the oldest courthouse in continuous use in the United States. The Mattaponi and Pamunkey Tribes operate fish hatcheries on the rivers. Residents and visitors enjoy the numerous recreational opportunities that the rivers provide.

The 2010 Census showed the King William County population to be 15,935 people, an increase of 2,789 (21.2%) from the 2000 Census. The population has 7,759 men and 8,176 women and is comprised of 12,297 whites, 2,819 African Americans, and 819 people of other races. Projections indicate that King William County will continue to experience moderate to accelerated population growth. By the year 2020, it is estimated that the County's population will grow at a rate of 8.62%, increasing the population by 1,373 persons. Growth management will become more important as competing uses vie for space and facilities.

Town of West Point

The Town of West Point lies at the extreme southern end of King William County where the Mattaponi and Pamunkey Rivers join to form the York River. The town is relatively flat, with large sections comprised of tidal marshes, particularly along the Mattaponi River. The highest elevations occur at the northern end of town at a height of 30+ feet above sea level. Most of the Pamunkey River waterfront is on a bluff averaging 20 feet in height. Union forces destroyed the town and the railroad, completed in 1859, during the Civil War. Only four houses survived the torching and remain intact today. West Point became an incorporated town in 1870. During the late 19th and early 20th centuries, West Point was a popular tourist destination. After the decline of tourism, a shipyard, built in 1917, and a pulp mill, built in 1918, revitalized the town.

The river areas surrounding the town are primarily used for recreation and barge access to the Meadwestvaco Rock Tenn Corporation where pulping operations convert wood chips, sawdust and recyclable paper products into pulp for use in producing various types of paperboard. The Old Dominion Grain Corporation also benefits from barge access.

The 2010 Census showed the population to be 3,306 people, an increase of 400 (15.4%) from the 2000 Census. The population has 1543 men and 1763 women and is comprised of 2618 whites, 509 African Americans, and 179 people of other races.

Mathews County

Mathews County is located at the eastern tip of the Middle Peninsula. The County is bordered mostly by water, with the Chesapeake Bay to the east, the Mobjack Bay to the south, the North River to the west, and the Piankatank River to the north. Except for approximately five miles that border Gloucester County, the County's perimeter is formed by its 217 mile shoreline. Mathews is predominantly a rural community that has attracted an increasing number of retirees and vacationers. More than half of the working residents earn their living outside the County. The mainstays of the local economy are agriculture, trade, seafood, and tourism.

Mathews County's population changed little between 1840 and 1900. The population peaked in 1910 with 8,922 residents, but gradually declined over the next five decades to a low point of 7,121 in 1960. This was in keeping with a national trend of population shifts from rural to urban areas because of the increased job opportunities in the cities. The population began to grow in the 1970's and it took until the mid 1990's before the population again reached the peak reported in 1910.

Much of the housing in Mathews is traditional single family dwellings, but the County also has a growing number of manufactured homes and vacant seasonal housing (built typically for summer occupancy). Seasonal housing, in the form of cottages, recreational vehicles, rental mobile homes, and a few condominium units increased in number from 448 in 1970, to 583 in 1980, to 783 in 1990. Residents of seasonal housing are often not accounted for in the census counts because the units were not occupied during the census survey. It is estimated that only about 75% of the housing units in Mathews County are occupied year-round, adding significantly to the summer population of Mathews County.

The 2010 Census showed the population to be 8,978 people, a decrease of 229 (-2.5%) from the 2000 census. The population has 4,363 men and 4,615 women and is comprised of 7,898 whites, 823 African

Americans, and 257 people of other races. Projections indicate that Mathews County will continue to experience low population growth. By the year 2020, it is estimated that the County's population will grow at a rate of 3.41%, increasing the population by 9,284 persons.

Middlesex County

Middlesex County, located at the eastern end of the Middle Peninsula, is comprised of 131 square miles of land and 135 linear miles of shoreline. The County is surrounded by three significant waterways; the Rappahannock River to the northeast, the Piankatank River to the southwest, the Chesapeake Bay to the east. The County is also bordered by Gloucester County to the southeast, King and Queen County to the West, and Essex County to the north. The geographic location of Middlesex County, particularly with the close proximity to two significant rivers, the Chesapeake Bay and the Atlantic Ocean, make Middlesex County communities much more vulnerable to tropical weather events, affecting the eastern seaboard of the United States. The county government operations are managed by a County Administrator, who is appointed by a five-person elected Board of Supervisors. The Government Seat, Board of Supervisors Meeting Room, and Courts Complex, are located in the area known as Saluda. The Middlesex County School System, is comprised of an Elementary, Middle and High School, with the School Board Administration Offices located in the Cooks Corner Office Building, just east of Saluda.

Middlesex has remained largely rural over the years, with farming, forestry, and fin and shell fishing providing the principal elements of the economic base. The County's relatively remote geographical location adds to the community's rural character. The 2013 Census reports the county population to be 10,762 full-time residents, a decrease of 197 (2%), from the 2010 census of 10,959. The population is made up by 5,413 females, and 5,349 males, comprised of 8,545 Whites, 1,937 African-Americans, and 280 people of other races. A total of 3,056 residents, or 28.4% of the population of Middlesex, are over 65 years-of-age. With the population dropping 2% in the past three years, it is estimated that the county's population will not see any drastic fluctuations, up or down, throughout the next decade.

The county population lives in 7,184 dwellings, with only 3.5% of the occupancies being comprised of multi-family dwelling units, a figure significantly lower than the Commonwealth's average of 21.7%. County officials estimate that 30% of the housing units in the community are seasonal, increasing the population between May and October with an additional 20,000 residents. Middlesex, Virginia, is home to one of the top boating populations in the Commonwealth of Virginia, another factor which adds to the seasonal population of the county.

Public Safety Services in Middlesex County are provided by the Office of the Sheriff, four individual volunteer fire companies, Deltaville, Hartfield, Urbanna, and Waterview; two volunteer rescue squads, Deltaville and Urbanna. The collective departments work hand-in-hand responding to law enforcement situations, fires, medical emergencies, and all-hazards incidents throughout the community. All Emergency Management activities, including operations of the Emergency Operations Center as well as maintenance and oversight of the Emergency Operations Plan, are managed by a county appointed Emergency Services Coordinator. This individual works in conjunction with the Middlesex Emergency Management Director, who is an appointed member, from the Board of Supervisors. The Emergency Services Coordinator also works in conjunction with the leadership and members of the volunteer fire departments and volunteer rescue squads.

Town of Urbanna

Urbanna is located in Middlesex County on the Rappahannock River on a finger of land bounded by Perkins Creek and Urbanna Creek. The town is one of America's original harbor towns and is located approximately five miles from Saluda, the current Middlesex County seat. Incorporated in 1902, the present town boundary comprises an area of about one-half square mile. The town operates an active boat harbor which is a major gateway for the fishing and recreational boating industries serving the area.

The 2010 Census showed the population to be 476 people, a decrease of 67 (-12.3%) from the 2000 Census. The population has 204 men and 272 women and is comprised of 431 whites, 35 African Americans, and 10 people of other races.

Of note to the economic value of tourism is that the Town Manager of Urbanna estimates that there is a seasonal swelling of the population to well above 2,000 people within the town and at the nearby Bethpage Campground due to seasonal use of vacation homes and campsites. This influx of tourists brings in much needed revenue and helps support the service industry and the tax base for the county.

The popular Urbanna Oyster Festival has been held in the town in November of each year since 1958. This annual event features oyster specialties and other Chesapeake Bay seafood, a parade, a fine arts exhibit and visiting tall ships. Crowds for the two-day event now number close to 75,000 people.

Section 4 – Hazard Identification and Risk Assessment

The hazard identification planning process utilized to update the 2016 plan involved discussions amongst community partners and input from the general public concerning the nature of hazards that threaten the Middle Peninsula. More specially, the stakeholders forming the Steering Committee identified hazards of the Middle Peninsula and how they should be prioritized as critical, moderately-critical and non-critical hazards. The Steering Committee also decided that an in depth analysis was needed for critical hazards. Non- Critical and moderately hazards were not re-analyzed with the exception of recent occurrences due to their minimal impact.

Based on the Federal Guidelines [Disaster Mitigation Act of 2000, *§201.1(b)]*, the Hazards Identification and Risk Assessment (HIRA) is only focused on natural hazards and their impacts. It measures potential loss of life, personal injury, economic impairment, and property damage resulting from natural hazards that threaten the Middle Peninsula. The Middle Peninsula HIRA involved:

1. Hazard Identification,
2. Risk Assessment Analysis, and
3. Financial Loss Estimations.

4.1 Hazard Identification

To begin, the Steering Committee reviewed and evaluated the 2010 list of natural hazards that could potentially affect the Middle Peninsula and added four new hazards that they deemed to be of concern to the region (Table 1).

Table 1: List of Natural Hazards	
• Hurricanes	• Earthquakes
• Ice Storms	• Shrink-swell Soils
• Tornadoes	• Extreme Cold
• Coastal Flooding/Nor-easters	• Extreme Heat
• Coastal/Shoreline Erosion	• Land Subsidence/Karst
• Sea Level Rise (added in 2010)	• Landslides
• Snow Storms	• Tsunamis
• Riverine Flooding	• Volcanoes
• Wildfires	• **Air Quality (added in 2016)**
• High Winds/Windstorms	• **HAZMAT (added in 2016)**
• Dam Failure	• **Ditch Flooding (added in 2016)**
• Droughts	• **Summer Storms (added in 2016)**
• Lightning	

In conjunction with the list of hazards, the Steering Committee reviewed the 2010 prioritization (Table 2) of natural hazards as a result of utilizing the Hazards Vulnerability Tool worksheet provided by VDEM staff (originally designed to estimate medical center hazard and vulnerability by Kaiser Permanente).

Table 2: Prioritization Worksheet for Hazards on the Middle Peninsula *(2010 worksheet)*

MIDDLE PENINSULA HAZARD AND VULNERABILITY ASSESSMENT TOOL
NATURAL HAZARDS – SUMMARY SHEET

EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY AND FACILITY IMPACT	BUSINESS IMPACT	Mitigation Options	UNMITIGATED RISK	RANKING
	Likelihood this will occur	Possibility of death or injury to public and responders	Physical losses and damages	COOP and Interruption of services	Pre-Planning	Relative Threat	Based only on probability and threat
SCORE	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 - 100%	
Hurricanes	3	3	3	3	2	92%	[illegible]
Winter Storms (Ice)	2	2	2	3	2	50%	[illegible]
Tornados	2	2	2	2	2	44%	[illegible]
Coastal Flooding	3	2	3	2	2	75%	[illegible]
Coastal/Shoreline Erosion	3	1	2	1	2	50%	[illegible]
Sea Level Rise	3	0	2	2	2	50%	[illegible]
Winter Storm (Snow)	2	2	2	2	2	44%	[illegible]
Wildfire	2	1	1	1	2	28%	[illegible]
Riverine Flooding	2	2	1	1	2	33%	
High Wind/Windstorms	2	2	2	1	1	33%	
Dam Failure	2	1	1	1	2	28%	
Drought	2	0	1	2	2	28%	
Lightning	3	1	2	2	1	50%	
Earthquake	1	0	0	0	0	0%	
Shrink-Swell Soils	2	0	1	0	1	11%	
Extreme Cold	1	2	0	0	1	8%	
Extreme Heat	2	2	0	0	1	17%	
Landslides	1	0	0	0	0	0%	
Land Subsidence/Karst	1	0	0	0	0	0%	
Tsunami	1	0	0	0	0	0%	
Volcano	0	0	0	0	0	0%	
AVERAGE	**2.27**	**1.27**	**1.67**	**1.53**	**1.67**	**25%**	

**Threat increases with percentage.*

UNMITIGATED RISK=		PROBABILITY * IMPACT	
	0.25	0.63	0.39

KAISER PERMANENTE.

Modifications by:
Revised: 2/25/2010

Similar to the 2006 and 2010 updates, the Steering Committee agreed to continue using the Kaiser Permanente Hazard Vulnerability Assessment Tool for this AHMP update. In doing so, this would provide a measure of continuity and consistency between the 2006, 2010 and 2016 MPAHMPs. Therefore the emergency services coordinator/manager from each of the nine jurisdictions were asked to complete the vulnerably worksheet for their locality and turn it into the MPPDC Regional Emergency Preparedness Planner. Emergency services coordinators/managers evaluated each hazard based on five criteria to rank the hazards from highest to lowest priorities. The five categories included the probability based on past events, the potential impacts to structures, primary impacts (percentage of damage to a typical structure or industry in the community), secondary impacts (based on impacts to the community at large), and potential mitigation options. The definitions given in Table 3 were used as a standard for evaluation of all the hazards.

Table 3: Prioritization Criteria for Hazards on the Middle Peninsula
Probability - *Frequency of occurrence based on historical data of all potential hazards*
Level 1 Unlikely (less than 1% occurrence: no events in the last 100 years) 2 Likely (between 1% and 10% occurrence: 1-10 events in last 100 years) 3 Highly Likely (over 10% occurrence: 11 events or more in last 100 years)
Affected Structures - *Number of Structures affected*
Level 0 None 1 Small (limited to 1 building) 2 Medium (limited to 2-10 buildings) 3 Large (over 10 buildings)
Primary Impacts - *Based on percentage of damage to a typical structure or industry in the community*
Level 0 None 1 Negligible (less than 3% damage) 2 Limited (between 3% and 49% damage) 3 Critical (more than 49% damage)
Secondary Impacts - *Based on impacts to the community at large*
Level 0 None 1 Negligible (no loss of function, no displacement time, no evacuations) 2 Limited (some loss of function, displacement time, some evacuations) 3 Critical (major loss of loss of function, displacement time, major evacuations)
Mitigation Options - *Number of cost effective mitigation options*
Level 0 None 1 Many (over 3 cost effective mitigation options) 2 Several (2-3 cost effective mitigation options) 3 Few (1 cost effective mitigation option)

After much consideration of the criteria, as well as readily available data, local knowledge and observations the Steering Committee members re-ranked the hazards for this update. Table 4 provides the new ranking of the hazards.

Table 4: Prioritization worksheet for Hazards in the Middle Peninsula for the 2016 update.

MIDDLE PENINSULA HAZARD AND VULNERABILITY ASSESSMENT TOOL
NATURAL HAZARDS -- SUMMARY SHEET
Priority Worksheet for Hazards

EVENT	PROBABILITY	HUMAN IMPACT	PROPERTY AND FACILITY IMPACT	BUSINESS IMPACT	Mitigation Options	UNMITIGATED RISK	UNMITIGATED RANKING
	Likelihood this will occur	*Possibility of death or injury to public and responders*	*Physical losses and damages*	*COOP and Interruption of services*	*Pre-Planning*	*Relative Threat*	*Based only on probability and threat*
SCORE	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 = N/A 1 = Low 2 = Moderate 3 = High	0 - 100%	
Winter Storms (Ice)	3	3	2	2	2	75%	1
Coastal Flooding	3	2	3	2	2	75%	1
Lightning	3	2	2	2	1	58%	2
Hurricanes	2	2	3	2	2	50%	3
Summer Storms	3	2	2	1	1	50%	3
Tornados	2	2	2	2	2	44%	4
Winter Storm (Snow)	2	2	2	2	2	44%	4
Coastal/Shoreline Erosion	2	2	2	1	2	39%	5
Wildfire	2	2	2	1	2	39%	5
Riverine Flooding	2	2	2	1	2	39%	5
Sea Level Rise	2	1	2	1	2	33%	6
High Wind/Windstorms	2	2	2	1	1	33%	6
HAZMAT	2	2	2	1	1	33%	6
Ditch Flooding	2	1	2	1	2	33%	6
Drought	2	1	2	1	1	28%	7
Extreme Cold	2	2	1	1	1	28%	7
Extreme Heat	2	2	1	1	1	28%	7
Dam Failure	1	1	1	1	1	11%	8
Earthquake	1	1	1	1	1	11%	8
Air Quality	1	1	1	1	1	11%	8
Shrink-Swell Soils	1	0	1	0	1	6%	9
Landslides	1	1	1	0	0	6%	9
Land Subsidence/Karst	1	0	0	0	0	0%	10
Tsunami	0	0	0	0	0	0%	10
Volcano	0	0	0	0	0	0%	10
AVERAGE	1.64	1.32	1.48	0.96	1.16	28%	

Threat increases with percentage.

UNMITIGATED RISK=		PROBABILITY * IMPACT	
	0.28	0.65	0.43

Spreadsheet developed by: KAISER PERMANENTE.

As an outcome of the reassessment and re-ranking of the natural hazards the five hazards that had the highest relative risk based on this analysis and are considered **"Critical Hazards"** included:

1. Winter Storms (Ice),
1. Coastal Flooding,
2. Lightning,
3. Hurricanes, and
3. Summer Storms

The hazards considered **"Moderately Critical"** are those that have historically occurred in the Middle Peninsula, yet ranked lower than the Critical Hazards in terms of risk during the hazard prioritization exercise. These Moderately-Critical hazards included:

4. Tornadoes,
4. Winter Storms (snow),

5. Coastal/shoreline Erosion,
5. Wildfires,
5. Riverine Flooding,
6. Sea Level Rise,
6. High Wind/Windstorms,
6. HAZMAT, and
6. Ditching Flooding

Hazards considered **"Non-Critical"** are those that have occurred very infrequently, or have not occurred at all – based on the available historical records. These hazards are not considered a widespread threat that would result in significant losses of property and life in the Middle Peninsula. These Non-Critical hazards included:

7. Drought,
7. Extreme Cold,
7. Extreme Heat,
8. Dam Failure,
8. Earthquake,
8. Air Quality,
9. Shrink-swell Soils,
9. Landside,
10. Land Subsidence/ Karst,
10. Tsunami, and
10. Volcano

4.2. Hazards Considered "Non-Critical" Hazards to the Middle Peninsula

The following sections describe natural hazards that are uncommon throughout the Middle Peninsula region and deemed "Non-Critical" Hazards to the Middle Peninsula by the Steering Committee. These hazards have occurred very infrequently, or have not occurred at all, in the available historical records and are not considered a widespread threat resulting in significant losses of property and life in the Middle Peninsula.

4.2.1. Drought

Empirical studies conducted over the past century have shown that drought is never the result of a single cause. It is the result of many causes, often synergistic in nature, and therefore often difficult to predict more than a month or more in advance. In fact, an area may already be in a drought before drought is even recognized. The immediate cause of drought is the predominant sinking motion of air (subsidence) that results in compressional warming or high pressure, which inhibits cloud formation and results in lower relative humidity and less precipitation. Regions under the influence of semi permanent high pressure during all or a major portion of the year are usually deserts, such as the Sahara and Kalahari deserts of Africa and the Gobi Desert of Asia. Most climatic regions experience varying degrees of dominance by high pressure, often depending on the season. Prolonged droughts occur when large-scale anomalies in atmospheric circulation patterns persist for months or seasons (or longer). The extreme drought that affected the United States and Canada during 1988 resulted from the persistence of a large-scale atmospheric circulation anomaly (National Drought Mitigation Center 2004).

Drought is a phenomenon that, in one form or another, affects the Commonwealth on nearly an annual basis. Drought has several definitions, depending upon the impact. Agricultural drought is the most common form of drought, and is characterized by unusually dry conditions during the growing season. Meteorological drought is defined as an extended period (generally 6 months or more) when precipitation is less than 75 percent of normal during that period. If coincident with the growing season, agricultural and meteorological drought can occur simultaneously. In general, hydrologic drought is the most serious, and has the most wide reaching consequences. Hydrologic drought occurs due to a protracted period of meteorological drought, which reduces stream flows to extremely low levels ("Dry years" in Figure 1), and creates major problems for public (reservoir/river) and private (well) water supplies.

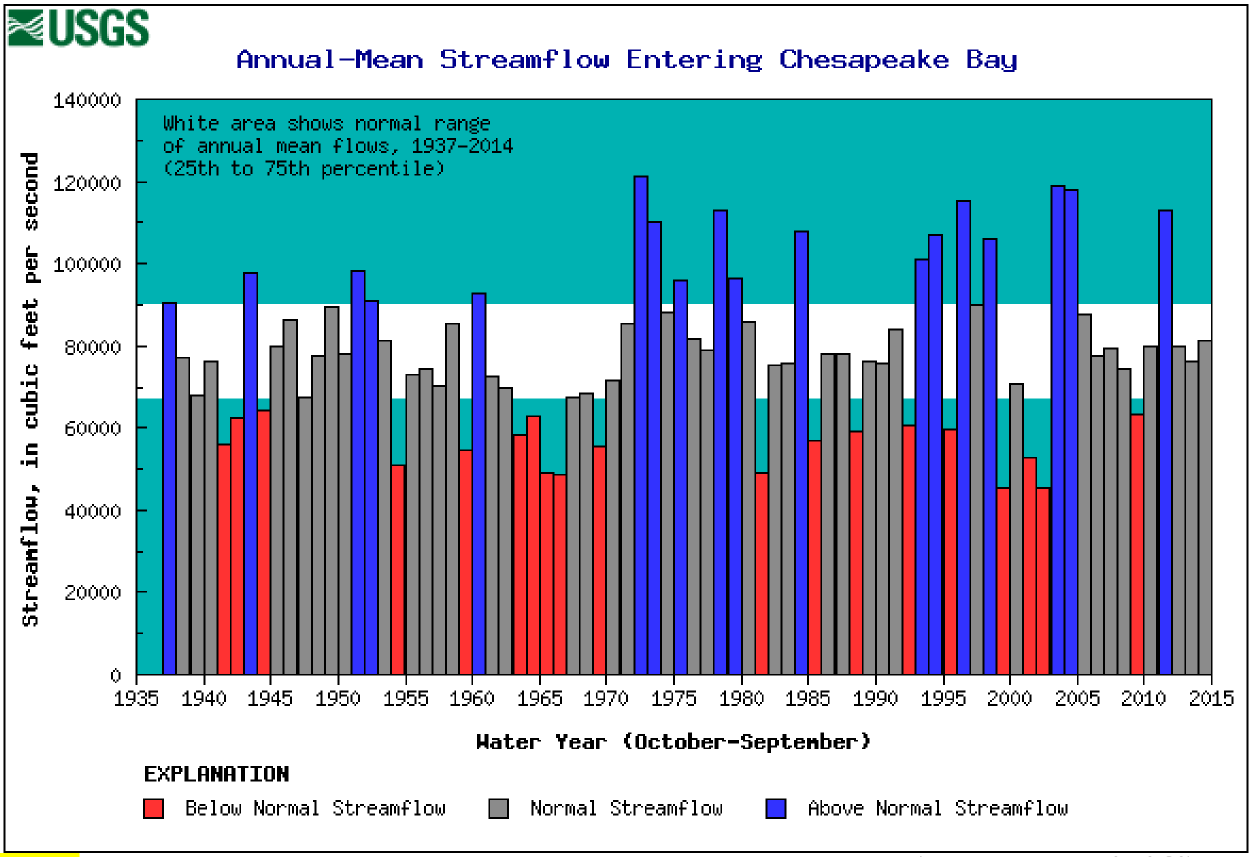


Figure 1: Annual mean stream inflow into Chesapeake Bay 1937 – 2015. *(Figure courtesy of USGS).*

Extended periods of drought can impact crop yields and hay yields, and significant crop losses can result. The impact of meteorological drought can vary significantly, depending upon dry years indicated by red bars the length of the dry period, the time of year the dry period occurs, the antecedent moisture conditions prior to the onset of the dry period, and the relative dryness (in percent of normal precipitation) of the period in question. Drought duration is highly variable by region. The duration also depends on when the precipitation is needed for such activities as planting and irrigation.

To assist in identifying the severity of a drought event a classification system is utilized and will dictate public water restriction (Table 5). Notice that water restrictions start as voluntary and then become required as the severity of the drought increases.

Table 5: Drought Severity Classification		
Category	**Description**	**Possible Impacts**
D0	Abnormally Dry	Going into drought: short-term dryness slowing planting, growth of crops or pastures; fire risk above average. Coming out of drought: some lingering water deficits; pastures or crops not fully recovered.
D1	Moderate Drought	Some damage to crops, pastures; fire risk high; streams, reservoirs, or wells low, some water shortages developing or imminent, voluntary water use restrictions requested
D2	Severe Drought	Crop or pasture losses likely; fire risk very high; water shortages common; water restrictions imposed
D3	Extreme Drought	Major crop/pasture losses; extreme fire danger; widespread water shortages or restrictions

There have been four major statewide droughts since the early 1900's (USGS 2002). The drought of 1930-32 was one of the most severe droughts recorded in the State. The droughts of 1938-42 and 1962-71 were less severe; however, the cumulative stream flow deficit for the 1962-71 drought was the greatest of the droughts because of its duration. The drought of 1980-82 was the least severe and had the shortest duration. Tidewater Virginia experienced "Severe Drought" conditions during the drought of 2001-2002 when stream flow into Chesapeake Bay was only half the average annual flow into the Bay (Virginia State Climatology Office, 2002).

In 2007 seventeen counties fell into severe drought status as over $10 million in crop damages occurred in Southwest Virginia.

Virginia is one of 44 states that have implemented a Drought Plan. The goals of these plans are to reduce water shortage impacts, personal hardships, and conflicts between water and other natural resource users. These plans promote self-reliance by systematically addressing issues of principal concern. The National Drought Policy Commission's report to Congress and the president, "Preparing for Drought in the 21st Century" (available on-line at: http://www.fsa.usda.gov/drought/finalreport/fullreport/pdf/reportfull.pdf), emphasizes the need for drought planning at the state, local, federal, and tribal levels of government. While some state plans focus on mitigation strategies, Virginia's Plan emphasizes response strategies.

In a parallel effort, Middle Peninsula localities with the exception of Gloucester County, participated in the development of the Middle Peninsula Regional Water Supply Plan (MPRWSP) in 2009. Gloucester County participated in the development of the Hampton Roads Regional Water Supply Plan. Overall the water supply plans contain proposed strategies and polices that the localities can undertake to mitigate adverse affects of periodic droughts

As both the Regional Water Supply Plan and Drought Response plans focuses on responding to drought, both plans should identify the role the jurisdiction's Emergency Services Coordinator/Manager will have with the locality's County Administrator/Town Manager during the implementation of both plans.

4.2.2. Extreme Cold and Extreme Heat

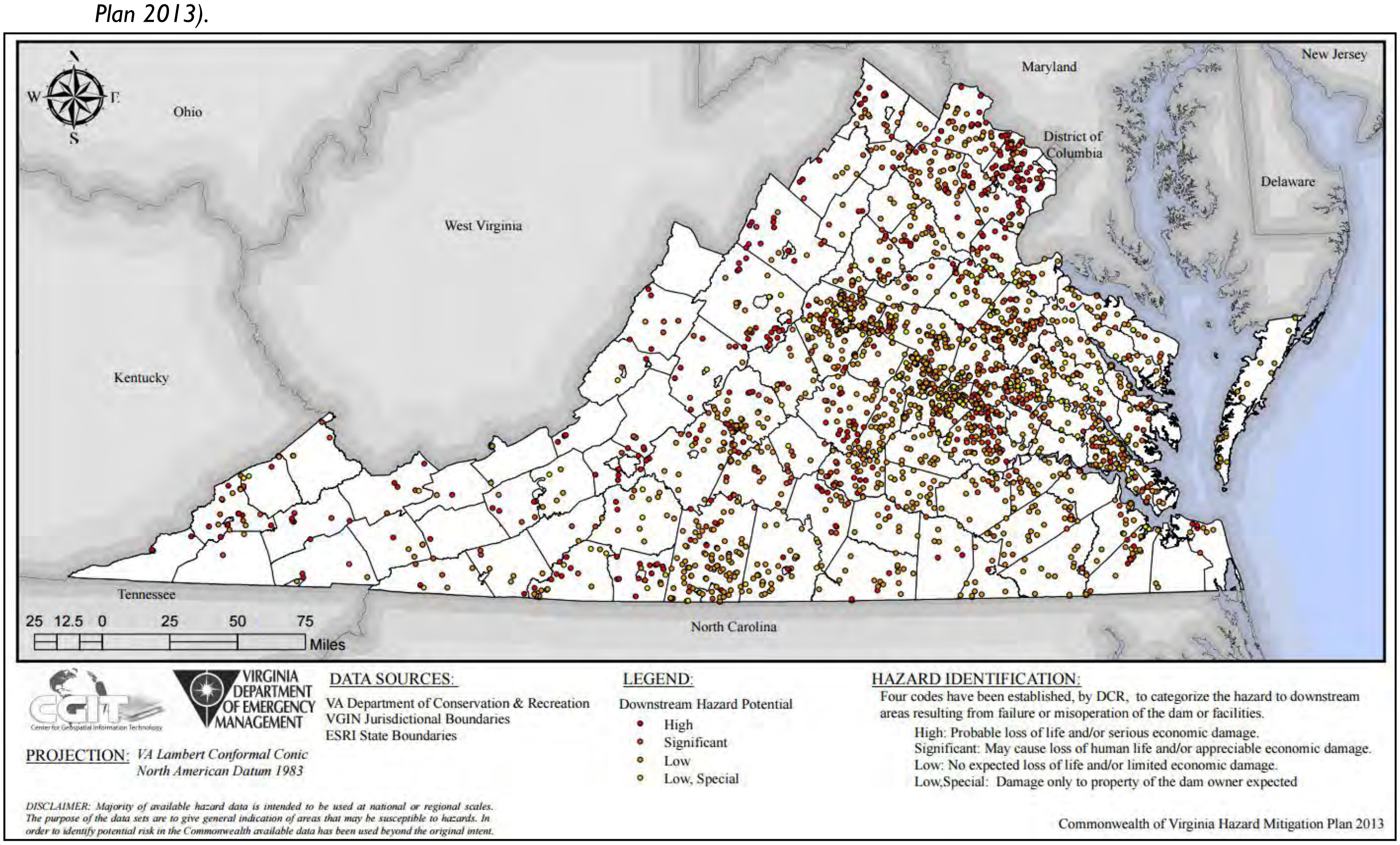
Extreme cold temperatures are not an annual event in Virginia. Although wind chill advisories are issued nearly every year, especially in Western and Northern portions of the state, life-threatening extreme cold, requiring wind chill warnings, is a rare occurrence in the Middle Peninsula. The frequency of occurrence is dependent entirely upon the extreme cold criteria used - wind chill vs. air temperature. The primary impact of extreme cold is increased potential for frostbite, hypothermia, and potentially death because of over-exposure to extreme cold. Some secondary impacts of extreme/excessive cold may present a danger to livestock and pets, and frozen water pipes in homes and businesses.

Extreme heat, generally associated with drought conditions, is a phenomenon that is generally confined to the months of July and August, although brief periods of excessive heat have occurred in June and September. Extreme heat can be defined either by actual air temperature, or by the heat index, which relates the combined effects of humidity and air temperature on the body. Extreme heat is not an annual event in the Middle Peninsula. Although heat advisories are issued near every year, especially in the urban areas of Northern Virginia, life-threatening extreme heat is a rare occurrence in the Middle Peninsula region. The frequency of occurrence is dependent entirely upon the extreme heat criteria used (i.e. heat index vs. air temperature). The primary impact of extreme heat is increased potential for hyperthermia, which can be fatal to the elderly and infirmed. In addition, there is an increased risk of dehydration, if proper steps are not taken to ingest adequate amounts of non-alcoholic fluids. The impact of extreme heat is most prevalent in urban areas, which are not found in the Middle Peninsula. Secondary impacts of excessive heat are severe strain on the electrical power system, and potential brownouts or blackouts.

4.2.3. Dam Failure

Since the last plan, the Virginia Department of Conservation and Recreation (DCR) created an inventory of dams throughout the Commonwealth. Based on this DCR data there are approximately 2,406 dams within the Commonwealth and approximately 101 in the Middle Peninsula (Table 6). Figure 2 provides a map of dam locations and their associated hazard potentials.

Figure 2: Dam locations and associated hazard potential *(Source: Commonwealth of Virginia Hazard Mitigation Plan 2013).*



As failure of dams may result in a localized major impact, including loss of human life, economic loss, lifeline disruption, and environmental impact such as destruction of habitat, there are also secondary impacts including flooding to the surrounding areas. Thus a scale has been developed to classify the hazard potentials of dams due to their overall impact to a given area:

- **High** – dams that upon failure would cause probable loss of life or serious economic damage.
- **Significant** – dams that upon failure might cause loss of life or appreciable economic damage.
- **Low** – dams that upon failure would lead to no expected loss of life or significant economic damage. This classification includes dams that upon failure would cause damage only to property of the dam owner. **Special criteria** – includes dams that upon failure would cause damage only to property of the dam owner.

Table 6: Inventory of dams within the Middle Peninsula and their risk classification.

County	High	Significant	Low	Low, Special	Unknown	Total # of Dams
Essex	0	1	15	1	0	17
Gloucester	1	3	6	1	0	11
King and Queen	0	6	8	7	1	22
King William	1	8	23	4	0	36
Mathews	0	0	0	0	0	0
Middlesex	0	2	11	2	0	15
TOTAL	2	20	63	15	1	101

Dams are classified with a hazard potential depending on the downstream losses estimated in event of failure. The recent regulatory revisions bring Virginia's classification system into alignment with the system already used in the National Inventory of Dams maintained by the U.S. Army Corps of Engineers. Hazard potential is not related to the structural integrity of a dam but strictly to the potential for adverse downstream effects if the dam were to fail. Regulatory requirements, such as the frequency of dam inspection, the standards for spillway design, and the extent of emergency operations plans, are dependent upon the dam classification.

Dams are classified with a hazard potential depending on the downstream losses estimated in event of failure. Hazard potential is not related to the structural integrity of a dam but strictly to the potential for adverse downstream effects if the dam were to fail. Frequency of dam inspection is dependent of how the dam is classified. The owner of each regulated Class I, II, and III dam is required to apply to the Soil and Water Conservation Board for an operation and maintenance certificate.

The Virginia Department of Conservation and Recreation, Division of Dam Safety's mission is to conserve, protect, enhance, and advocate the wise use of the Commonwealth's unique natural, historical, recreational, scenic and cultural resources. The program's purpose is to provide for safe design, construction, operation, and maintenance of dams to protect public safety. Disaster recovery programs include assistance to dam owners and local officials in assessing the condition of dams following a flood disaster and assuring the repairs and reconstruction of damaged structures are compliant with the National Flood Insurance Program (NFIP) regulations.

For those dam failures that pose a risk when there are large potential areas with large populations surrounding dams. On-going dam inspections and Virginia's participation in the National Dam Safety Program maintained by FEMA and the U.S. Army Corps of Engineers serve as preventative measures against dam failures.

Most dam failures occur due to lack of maintenance of dam facilities in combination with excess precipitation events, such as hurricanes and thunderstorms. During Hurricane Floyd in 1999, floods broke open at least 12 unregulated dams in eastern Virginia. One of those failures, at the Cow Creek Dam near Gloucester Courthouse, temporarily closed state Route 14; No one was hurt. Rebuilding the dam cost about $160,000 (U.S. Water News Online 2002). During Tropical Storm Gaston in late summer of 2004, a dam was overtopped in King William County and caused a washout of Route 610 between Rt. 608 and Rt. 609. The road was closed to traffic for several weeks (VDOT 2004).

Dam Impoundments

In 2001, Virginia's legislature broadened the definitions of "impounding structure" to bring more dams under regulatory oversight. On February 1, 2008, the Virginia Soil and Water Conservation Board approved major revisions to the Impounding Structure Regulations in the Virginia Administrative Code, changing the dam hazard potential classification system, modifying spillway requirements, requiring dam break inundation zone modeling, expanding emergency action plan requirements, and making a variety of other regulatory changes.

All dams in Virginia are subject to the Virginia Dam Safety Act and Dam Safety Regulations unless specifically excluded. A dam is excluded from these regulations if it meets one or more of the following criteria:

1. is less than 6 feet high,
2. has a maximum capacity of less than 50 acre-feet and is less than 25 feet in height,
3. has a maximum capacity of less than 15 acre-feet and is more than 25 feet in height,
4. is used primarily for agricultural purposes and has a maximum capacity of less than 100 acre-feet or is less than 25 feet in height (if the use or ownership changes, the dam may be subject to the Dam Safety Regulations),
5. is owned or licensed by the federal government,
6. is operated for mining purposes under 45.1-222 or 45.1-225.1 of the Code of Virginia, or
7. is an obstruction in a canal used to raise or lower water levels.

The height of the dam is defined as the vertical distance from the streambed at the downstream toe to the top of the dam. The maximum capacity of a dam is defined as the maximum volume capable of being impounded at the top of the dam.

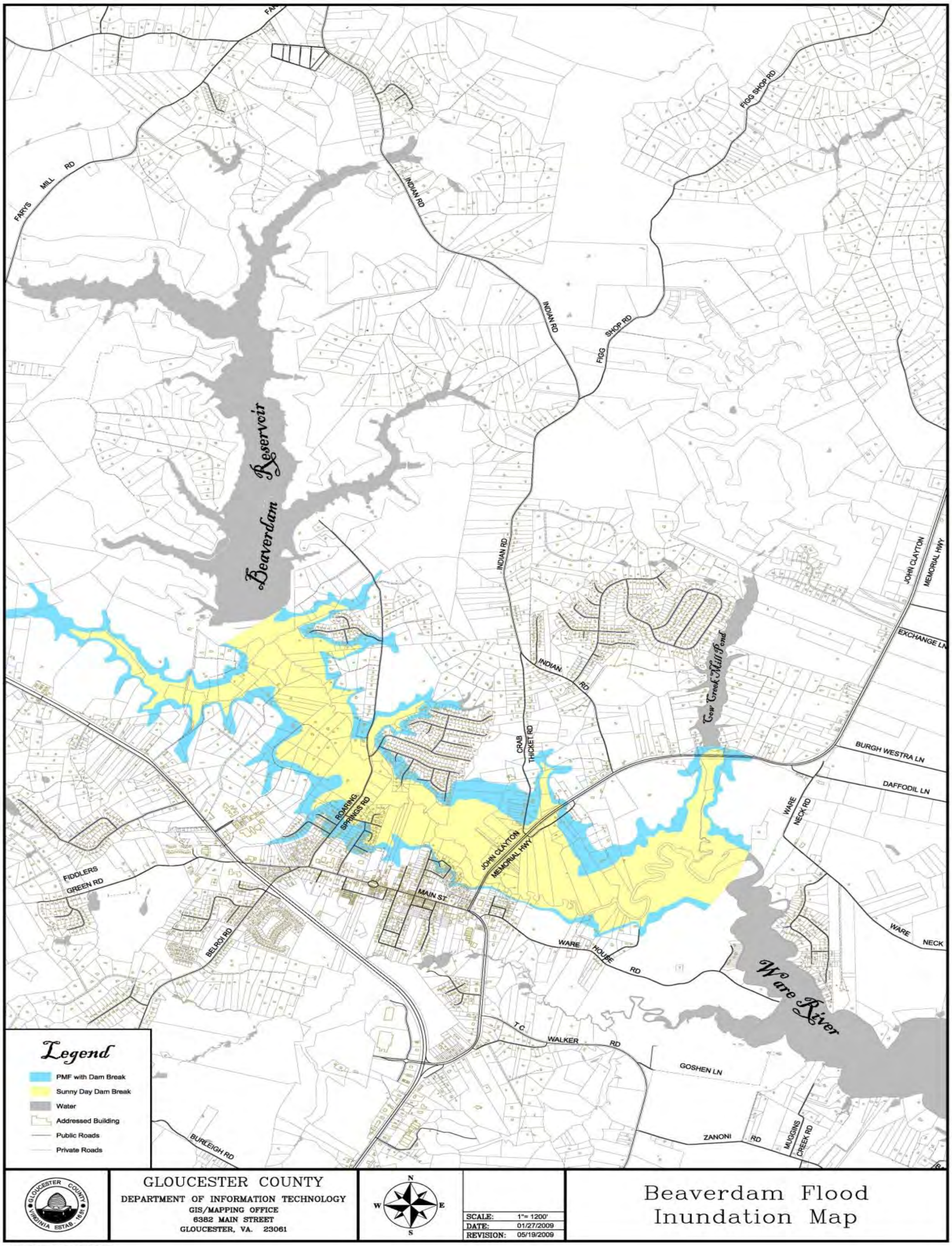
The Virginia Department of Conservation and Recreation (VDCR) – Division of Dam Safety is the state agency responsible for enforcing the Virginia Dam Safety Act and overseeing the issuance of Operation and Maintenance Certificates for regulated dams.

Beaverdam Reservoir Dam – Gloucester, County

The Beaverdam Reservoir, located to the north of the Gloucester Courthouse area, is contained by a 39' high dam structure and covers approximately 635 acres of land. The reservoir is primarily surrounded by land zoned for low density development and there is a 300' by 600' buffer area surrounding this water impoundment. The property is owned by Gloucester County and it is an actively used local recreational site known as Beaverdam Park as well as a drinking water source for Gloucester County residents.

Figure 3 shows areas shaded in yellow and blue that would be inundated if the reservoir dam were to fail. According to Gloucester County officials, these shaded areas represent 405 homes just north of the Gloucester Courthouse Complex and the downtown business district that would be inundated if the dam were to fail.

Figure 3: Beaverdam. *Flood Inundation Map (Source: Gloucester County)*



Lake Anna Dam

The Lake Anna Dam, located near Mineral in Louisa County, Virginia, creates an impoundment with a surface area of approximately 13,000 acres. Periodic major water releases from Lake Anna flow into the Pamunkey River which can have adverse affects on river levels during major releases.

Depending on the amount of water released by the dam owner, Dominion/Virginia Power Company, a potential flooding hazard exists for King William County residents, which would include flooding of low-lying agricultural land, some roads, threes (3) bridges along these roads, a scattering of residences and some agricultural structures.

4.2.4. Earthquakes

An earthquake is a sudden movement or trembling of the Earth, caused by the abrupt release of strain that has accumulated over a long time. For hundreds of millions of years, the forces of plate tectonics have shaped the Earth as the huge plates that form the Earth's surface slowly move over, under, and past each other. Sometimes the movement is gradual; at other times, the plates are locked together, unable to release the accumulating energy. When the accumulated energy grows strong enough, the plates break free and result in an earthquake (Shedlock and Pakister 1997). If the earthquake occurs in a populated area, it may cause deaths, injuries, and extensive property damage.

During an earthquake when the ground is shaking, it experiences acceleration. The peak acceleration (PA) is the largest acceleration recorded by a particular station during an earthquake (expressed as %g). When acceleration acts on a physical body, the body experiences the acceleration as a force. The force we are most experienced with is the force of gravity, which causes us to have weight. Units of acceleration are measured in terms of g, the acceleration due to gravity. For example, an acceleration of 11 feet per second per second is 11*12*2.54 = 335 cm/sec/sec. The acceleration due to gravity is 980 cm/sec/sec, so an acceleration of 11 feet/sec/sec is about 335/980= 0.34 g. Expressed as a percent; 0.34 g is 34 %g.

The United States Geological Survey (USGS) rates the susceptibility of areas of the United States to earthquakes and has published risk maps, which give the probability of various levels of ground motion being exceeded in 5 years. An approximate threshold for shaking that causes building damage (for pre-1965 dwellings or dwellings not designed to resist earthquakes) is 10 %g. According to USGS predictions, the Middle Peninsula is located within the 1-2%g, 2-3%g and 3-4%g contour lines (Figure 4).

Historical data is supportive of this low risk assessment. Virginia has had over 160 earthquakes since 1977 of which 16% were felt (Stover and Coffman 1993). This equates to an average of one earthquake occurring every month with two felt each year. Figure 5 depicts the historical earthquake epicenters in and near Virginia from 1568 through 2011. The largest earthquake in Virginia was a magnitude 5.8 earthquake in Giles County in 1897. This earthquake was the third largest in the eastern US in the last 200 years was felt in twelve states. Based on the map there were no earthquake epicenters recorded within the area of the Middle Peninsula. However in 2011 a 5.8 earthquake in Mineral, Virginia was felt in the Middle Peninsula region and causes damages according to VDEM (Figure 6).

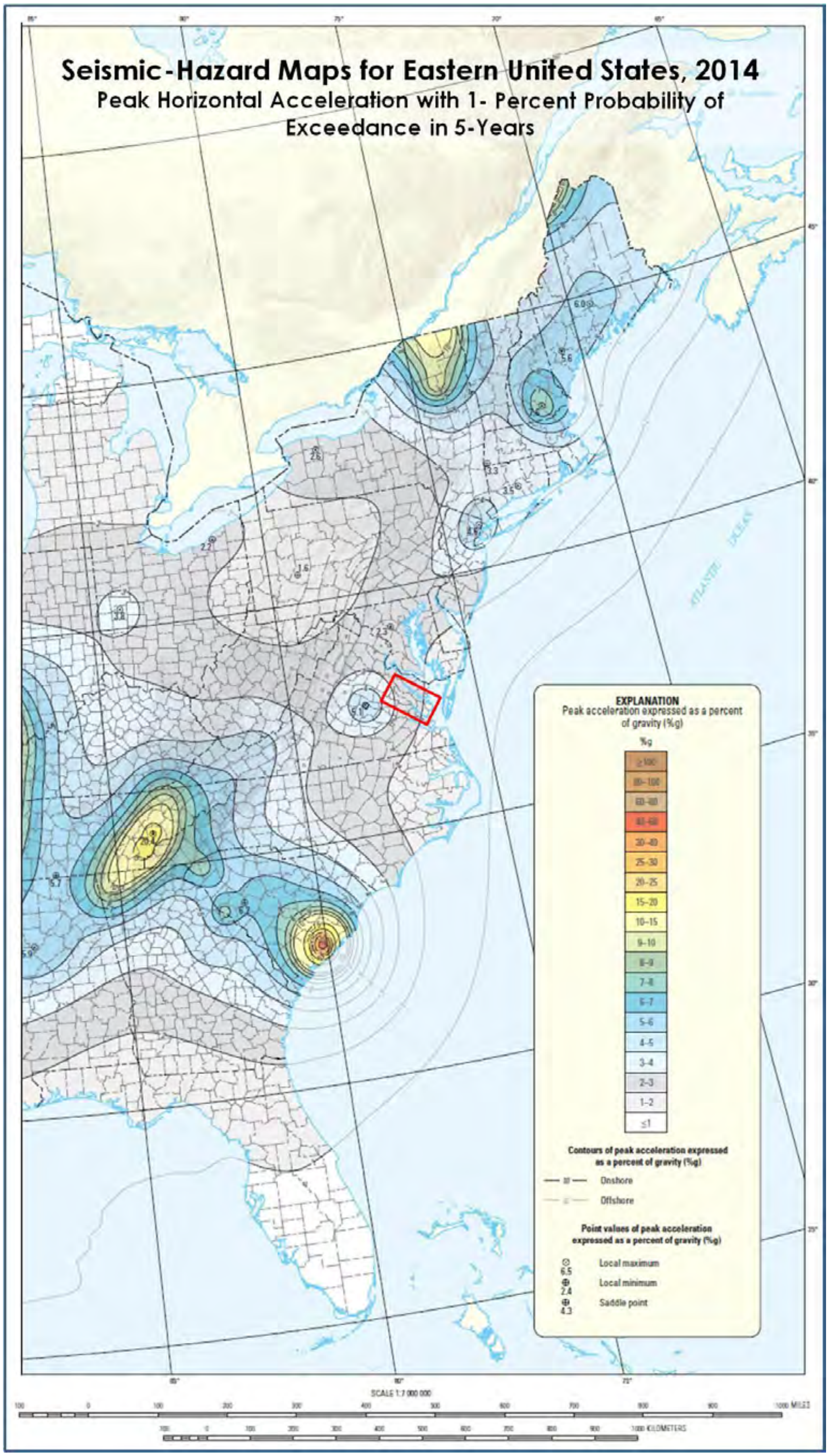


Figure 4: Seismic- Hazard Map of the Eastern United States. *Predicted earthquake hazards are depicted by contour values of earthquake ground motions that have a 1% probability if being exceeded in 5 years. The Middle Peninsula of Virginia (hi-lighted by the red square on the map) falls within the 1-2%g, 2-3%g and 3-4%g contour. Image courtesy of Pattersen, et. al. with USGS (2015)*

Figure 5: Significant Earthquakes 1568 – 2011 - *Historical earthquake epicenters in and near Virginia from 1568 through 2011. The Middle Peninsula of Virginia (highlighted by the red square on the map) is void of any historic earthquake epicenters (Source: Commonwealth of Virginia Hazard Mitigation Plan 2013).*

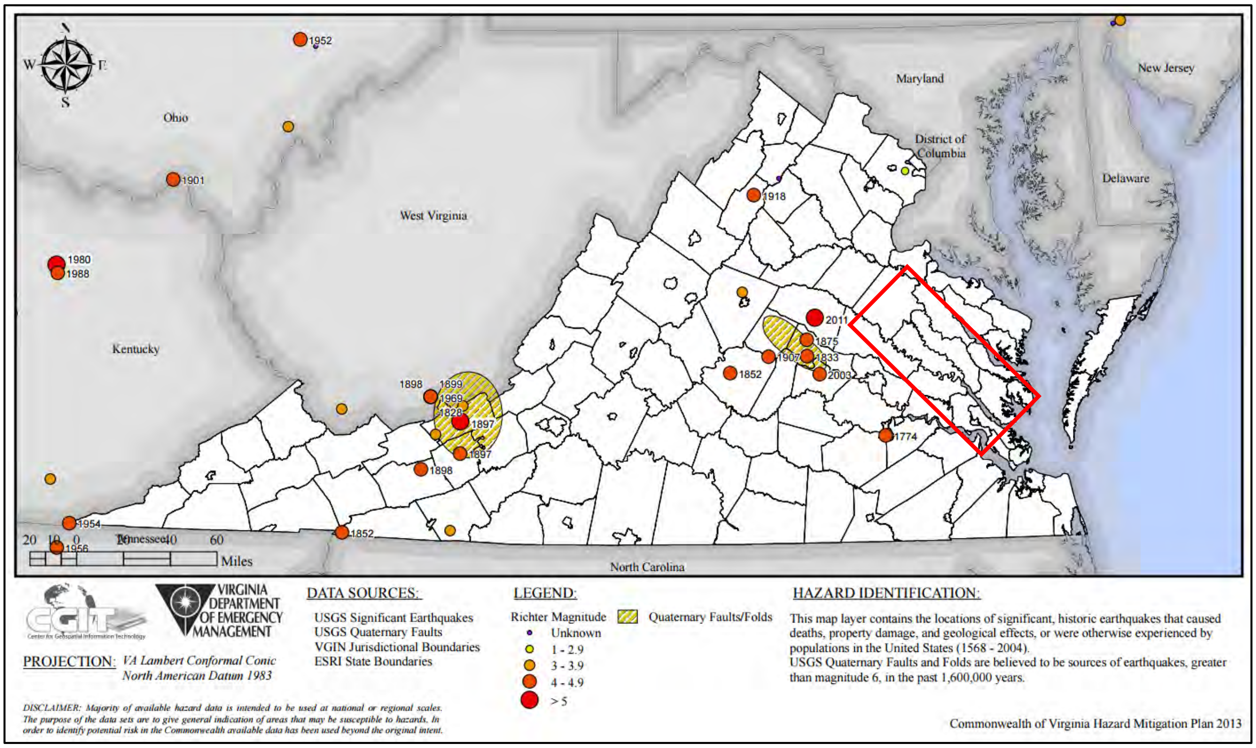
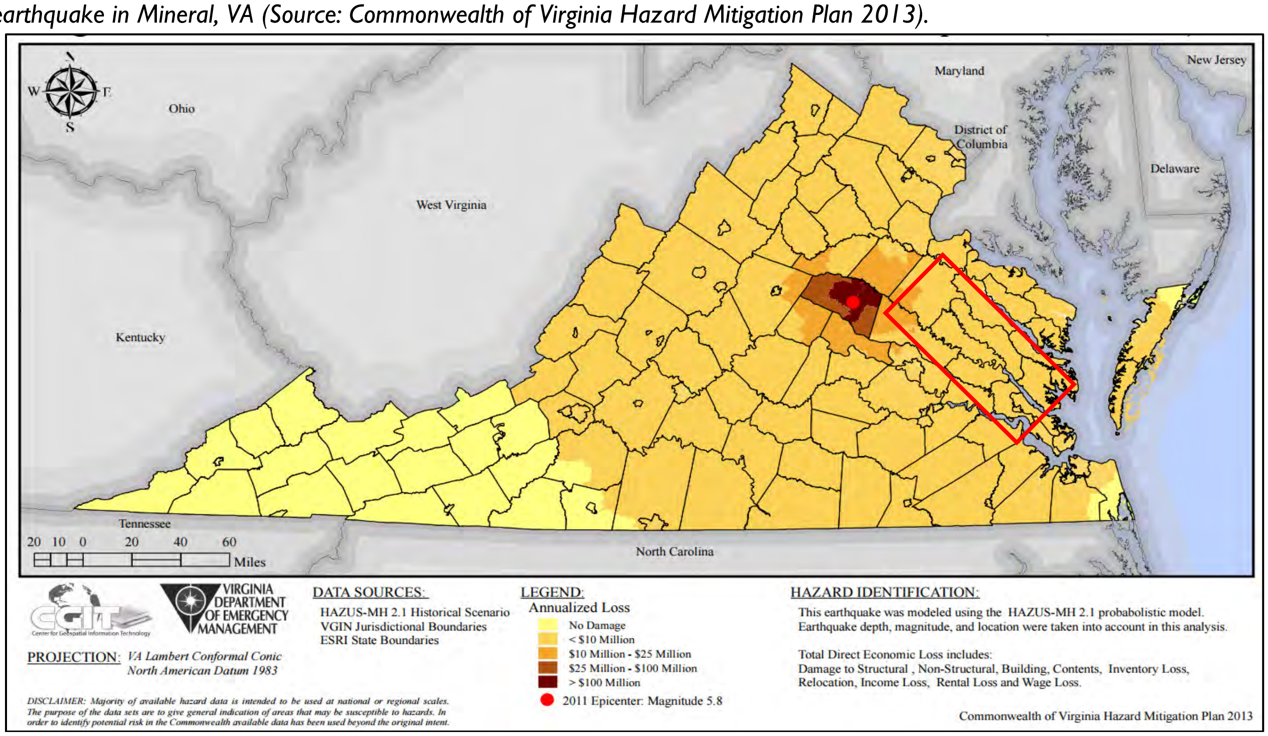


Figure 6: Total loss from 2011 Mineral, VA Earthquake (HAZUS). *The Middle Peninsula of Virginia (highlighted by the red square) is void of any historic earthquake epicenters, however endured losses as a result of impact from the 2011 earthquake in Mineral, VA (Source: Commonwealth of Virginia Hazard Mitigation Plan 2013).*



Earthquake Extent (Impact)

The severity of an earthquake can be expressed in terms of both intensity and magnitude. However, the two terms are quite different, and they are often confused. Intensity is based on the observed effects of ground shaking on people, buildings, and natural features. It varies from place to place within the disturbed region depending on the location of the observer with respect to the earthquake epicenter. Magnitude is related to the amount of seismic energy released at the hypocenter of the earthquake. It is based on the amplitude of the earthquake waves recorded on instruments which have a common calibration. The magnitude of an earthquake is thus represented by a single, instrumentally determined value.

Earthquake severity is commonly measured on two different scales: the Modified Mercalli Intensity scale and the Richter Magnitude scale. The following provides ranking and classification definitions for the two scales (Table 7).

Table 6: Ranking and classification definitions for two scales that measure earthquake severity.

Richter Magnitude Scale	Modified Mercalli Intensity Scale
1.0 to 3.0	I
3.0 to 3.9	II to III
4.0 to 4.9	IV to V
5.0 to 5.9	VI to VII
6.0 to 6.9	VII to IX
7.0 and Higher	VIII or Higher
Defined Modified Mercalli Intensity Scale Rating	
I	Not Felt except by a very few under especially favorable conditions
II	Felt only by a few persons at rest, especially on upper floors of buildings
III	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck.
IV	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors, disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken
VIII	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned
IX	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.
XI	Few, if any (masonry) structures remain standing. Bridges destroyed. Rails bent greatly.
XII	Damage total. Lines of sight and level are distorted. Objects thrown into the air.

4.2.3. Air Quality

Good air quality is taken for granted by most of the citizens of the Middle Peninsula of Virginia. However there are natural and human-caused factors that may influence the air quality within the region.

First emissions from human activity can influence overall air quality within the region. From vehicle emissions to local businesses (ie. industry), Virginia Department of Environmental Quality Air Division's monitors and regulates emissions as they responsible for carrying out the mandates of the Virginia Air Pollution Control Law as well as the Federal obligations under the Clean Air Act on behalf of the State Air Pollution Control Board. For local industry, DEQ issues air quality permits to regulate emitted pollutants to ensure that these emissions do not cause harm to the public or the environment. Each year DEQ will compile an inventory of criteria pollutants air emissions from point, area, mobile and biogenic sources (ie. natural sources, from vegetation and soils as well as other relevant sources include volcanic emissions, lightning, and sea salt). Table 7 displays the most recent 2013 Point Source Criteria Pollutant Emissions Report for Middle Peninsula localities.

Table 7: 2013 Point Source Emissions Inventory *DEQ periodically compiles an inventory of criteria pollutant air emissions from point, area, mobile, and biogenic sources in the state. Point source emissions are inventoried annually.*

County	Plant Name	Emissions (tons)							
		NH_3	NO_2	PB	PM 10	PM 2.5	SO_2	VOC	Plant Total
Essex	Tidewater Lumber				35.55	35.55			71.11
Essex	June Parker Oil Co Inc							2.31	2.31
Essex	FDP Brakes of Virginia		1.80		2.64	2.64	0.00	14.83	22.14
Essex	Perdue Foods LLC - Tappahannock/Essex		0.75		16.06	15.51	0.00	0.03	32.45
Essex	Essex Concrete Corporation - Tappahannock				0.46	0.46			0.93
Essex	O'Malley Timber Products, Inc.	0.00	9.96		16.24	7.70	1.13	26.82	89.02
Gloucester	Rappahannock Concrete White Marsh		0.02		0.36	0.36	0.04	0.00	0.79
Gloucester	Philips Energy Inc							5.91	5.91
Gloucester	Riverside Walter Reed Hospital	0.04	0.74	0.00	0.09	0.08	0.24	0.01	1.39
Gloucester	Rappahannock Concrete Saluda				0.27	0.27			0.54
Gloucester	Canon Environmental Technologies Incorporated				27.80	27.80			55.59
Gloucester	Middle Peninsula Landfill		109.27		17.73	17.08	4.69	15.25	368.33
Gloucester	C. W. Davis Asphalt Division				0.14	0.14			0.29
Gloucester	Hogg Funeral Home				0.01	0.01			0.04
Gloucester	Contract Crushing/Construction Inc		0.00		0.06	0.06		0.00	0.13
Gloucester	Branscome Incorporated - Gloucester				0.36				0.36
Gloucester	Mid Atlantic Materials Incorporated - Gloucester				2.28	0.41			2.69
Gloucester	Shadow Farms Animal Cremation Services Inc		0.00		0.00				0.00
King and Queen	Ball Lumber Company Incorporated		9.42	0.00	24.77	11.25	1.07	45.72	117.92
King and Queen	Bennett Mineral Company Inc		2.87	0.00	1.07	0.99	1.13	1.36	57.30
King and Queen	Essex Concrete Corporation - Aylett				6.28	6.28			12.56
King and Queen	BFI King and Queen Landfill		24.21		10.45	7.42	6.19	18.05	146.98
King and Queen	INGENCO - King and Queen		96.87		57.45	57.45	0.17	76.12	407.41
King and Queen	Helena Chemical Company - Portable 52353				0.12	0.11		0.00	0.22

King William	West Point Veneer LLC	0.00	5.28	0.00	10.13	10.13	0.27	36.24	71.76
King William	Trible-Perry Oil Co/PAPCO Oil Co.							3.85	3.85
King William	RockTenn CP LLC - West Point	64.45	1717.38	0.14	489.52	455.36	814.68	599.83	5524.43
King William	Old Dominion Grain		2.18	0.00	18.04	3.13	0.00	0.06	23.77
King William	Augusta Wood Products LC - Sawmill		1.28	0.00	11.62	11.62	0.25	14.51	48.55
King William	NPPC King William		45.16		38.25	38.25	0.23	1.02	138.97
King William	West Point Chips Incorporated				40.43	40.43			80.85
King William	Aggregate Industries MAR - Mattaponi Plant				0.12	0.12			0.24
King William	Powerhouse Equipment and Engineering Co Inc		0.00		0.00		0.00	0.00	0.00
King William	Cross Land Harbour LLC				0.43	0.43			0.86
King William	Powerhouse Equipment and Enginrng - Portable 52322		11.20		0.56		3.98		18.54
King William	Gillies Creek Recycling Center - Portable 52420		4.90		1.19		0.32	0.08	7.40
King William	Vincent Funeral Home - West Point		0.00		0.00		0.00	0.00	0.00
Mathews	Wroten Oil Company							2.67	2.67
Middlesex	J T and C A Thrift Incorporated							2.01	2.01
Total Regional Admissions		**64.49**	**2043.29**	**0.15**	**830.5**	**751.05**	**834.4**	**866.65**	**866.65**
**Note: Blank squares within the table indicate that there are no emissions to be measured.									

With the passing of the Clean Air Act in 1970 and then amendments in 1990, the US Congress required DEQ to enhance the vehicle emissions inspection program in order to keep improving air quality and to reduce emission further. In response Virginia now requires the inspection of vehicles operating in the counties of Arlington, Fairfax, Loudoun, Prince William, Stafford and the Cities of Alexandria, Fairfax, Falls Church, Manassas and Manassas Park. Vehicle emission contain pullulates that contribute to the formation of ozone, the main component of smog that builds up at ground level in hot sunny weather and may impact water quality in the Chesapeake Bay and its tributaries (ie. through atmospheric deposition).

In conjunction with emissions caused by humans there are natural, such as forest fires and controlled burns, may cause the air quality to deteriorate and become unsafe, especially for those who suffer medical conditions that make them sensitive to poor air quality. As a rural region of Virginia, the Middle Peninsula landscape is dominated by fields and forests. To properly manage these resources, property owners may carry out prescribed burning, a deliberate use of fire under specified and controlled conditions to achieve a resource management goal. Benefits including:

- site preparation for reforesting,
- hardwood control in pine stands,
- wildfire hazard reduction,
- improved wildlife habitat, and
- threatened and endangered species management.

According to the VDOF:
Products from the combustion of forest fuels are mainly carbon-containing compounds. The most important pollutants being particulate matter and carbon monoxide (CO).

Two products of complete combustion are carbon dioxide (CO_2) and water, these make up over 90% of the total emissions. Under ideal conditions it takes 3.5 tons of air to completely burn 1 ton of fuel. The combustion of 1 ton o *of fuel will produce the following:*

Carbon dioxide (CO2)	*2,000 to 3,500 lbs*
Water Vapor	*500 to 1,500 lbs*
Particulate Matter	*10 to 2000 lbs*
Carbon Monoxide (CO)	*20 to 500 lbs*
Hydrocarbons	*4 to 40 lbs*
Nitrogen Oxides	*1 to 9 lbs*
Sulfur Oxide	*Negligible amounts*

To assist with the management of the smoke generated from prescribed burning, the VDOF has developed voluntary smoke management guidelines to lessen the public health and welfare impacts (www.dof.virginia.gov/resources/fire/prescribed-fire-smoke-mgmt.pdf). In additional to prescribed burns there are also unplanned forest fires that would impact the region's air quality. For instance, on August 4, 2011, a lightning strike caused a fire in the Great Dismal Swamp that kept smoldering for 111 days. This impacted air quality impacted Southern Virginia, Middle Peninsula Localities as well as northward across Virginia and as far as Annapolis, Maryland. Wind currents over the Chesapeake Bay provided a channel for the ash-heavy smoke to travel north and caused a CODE ORANGE (See Table 8 below) for most of coastal Virginia.

Air Quality (Extent)
To monitor and assess daily air quality, the Environmental Protection Agency (EPA) has established the Air Quality Index (AQI). This scale determines how clean or polluted the air is and its impacts on human health. Based on a 0-500 scale, the higher the AQI value the greater the level of air pollutions and the greater the health concern. Table 8 identifies the AQI levels of health concern, the associated numerical value and the meaning:

Table 8: AQI Scale. *AQI levels and associated numerical values and meaning of the index (Source: AirNow.gov).*

Air Quality Index Levels of Health Concern	Numerical Value	Meaning
Good	0 to 50	Air Quality is considered satisfactory, and air pollution poses little or no risk
Moderate	51 to 100	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution
Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is not likely to be affected.
Unhealthy	151 to 200	Everyone may begin to experience health effects; members of sensible groups may experience more serious health effects
Very Unhealthy	201 to 300	Health warning of emergency conditions. The entire population is more likely to be affected.
Hazardous	301 to 500	Health alert: everyone may experience more serious health effects

Based on this scale the EPA will calculate daily AQI number for each of the five major air pollutants regulated by the Clean Air Act, including ground ozone, particle pollution, carbon dioxide, sulfur dioxide, and nitrogen dioxide (Table 9).

Table 9: Description of regulated pollutants (Source: AirNow.gov).	
Pollutant	**Description**
Ozone (O_3)	Ozone is a form of oxygen with three atoms instead of the usual two atoms. It is a photochemical oxidant and, at ground level, is the main component of smog. Unlike other gaseous pollutants, ozone is not emitted directly into the atmosphere. Instead, it is created in the atmosphere by the action of sunlight on volatile organic compounds and nitrogen oxides. Higher levels of ozone usually occur on sunny days with light winds, primarily from March through October. An ozone exceedance day is counted if the measured eight-hour average ozone concentration exceeds the standards.
Carbon Monoxide (CO)	Carbon Monoxide (CO) is a colorless, odorless, very toxic gas produced by the incomplete combustion of carbon-containing fuels, most notably by gasoline powered engines, power plants, and wood fires. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.
Sulfur Dioxide (SO_2)	Sulfur dioxide (SO_2) is one of a group of highly reactive gasses known as "oxides of sulfur." The largest sources of SO_2 emissions are from fossil fuel combustion at power plants (73%) and other industrial facilities (20%). Smaller sources of SO_2 emissions include industrial processes such as extracting metal from ore, and the burning of high sulfur containing fuels by locomotives, large ships, and non-road equipment. SO_2 is linked with a number of adverse effects on the respiratory system.
Nitrogen Dioxide (NO_2)	Nitrogen dioxide (NO_2) is one of a group of highly reactive gasses known as "oxides of nitrogen", or "nitrogen oxides (NO_x)". Other nitrogen oxides include nitrous acid and nitric acid. While EPA's National Ambient Air Quality Standard covers this entire group of NO_x, NO_2 is the component of greatest interest and the indicator for the larger group of nitrogen oxides. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone and fine particle pollution, NO_2 is linked with a number of adverse effects on the respiratory system.
Particulate Matter (PM-2.5 PM-10)	Particle pollution (also called particulate matter or PM) is the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small, they can only be detected using an electron microscope. Particle pollution includes *inhalable coarse particles*, with diameters larger than 2.5 micrometers and smaller than 10 micrometers and *fine particles*, with diameters that are 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter -- making it 30 times larger than the largest fine particle. These particles come in many sizes and shapes and can be made up of hundreds of different chemicals. Some particles, known as *primary particles*, are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires. Others form in complicated reactions in the atmosphere of chemicals such as sulfur dioxides and nitrogen oxides that are emitted from power plants, industries and automobiles. These particles, known as *secondary particles*, make up most of the fine particle pollution in the country. Coarse particulates (PM-10) come from sources such as windblown dust from the desert or agricultural fields (sand storms) and dust kicked up on unpaved roads by vehicle traffic. PM-10 data is the near real-time measurement of particulate matter 10 microns or less in size from the surrounding air. This measurement is made at standard conditions, meaning it is corrected for local temperature and pressure. Fine particulates (PM-2.5) are generally emitted from activities such as industrial and residential combustion and from vehicle exhaust. Fine particles are also formed in the atmosphere when gases such as sulfur dioxide, nitrogen oxides, and volatile organic compounds, emitted by combustion activities, are transformed by chemical reactions in the air. Large-scale agricultural burning or sand storms can produce huge volumes of fine particulates. PM-2.5 data is the near real-time measurement of particulate matter 2.5 microns or less in size from the surrounding air. This measurement is made at local conditions, and is not corrected for temperature or pressure.

AirNow.com provides a daily air quality forecast for select regions of Virginia including Hampton Roads, Northern Virginia, Richmond, Roanoke, Shenandoah National Park and Winchester. This site also provides calendars of air quality nationally as well as at the state level (Figure 8 & 9).

Figure 8: Calendar of air quality *throughout across the nation (Source: AirNow.com, 2015).*

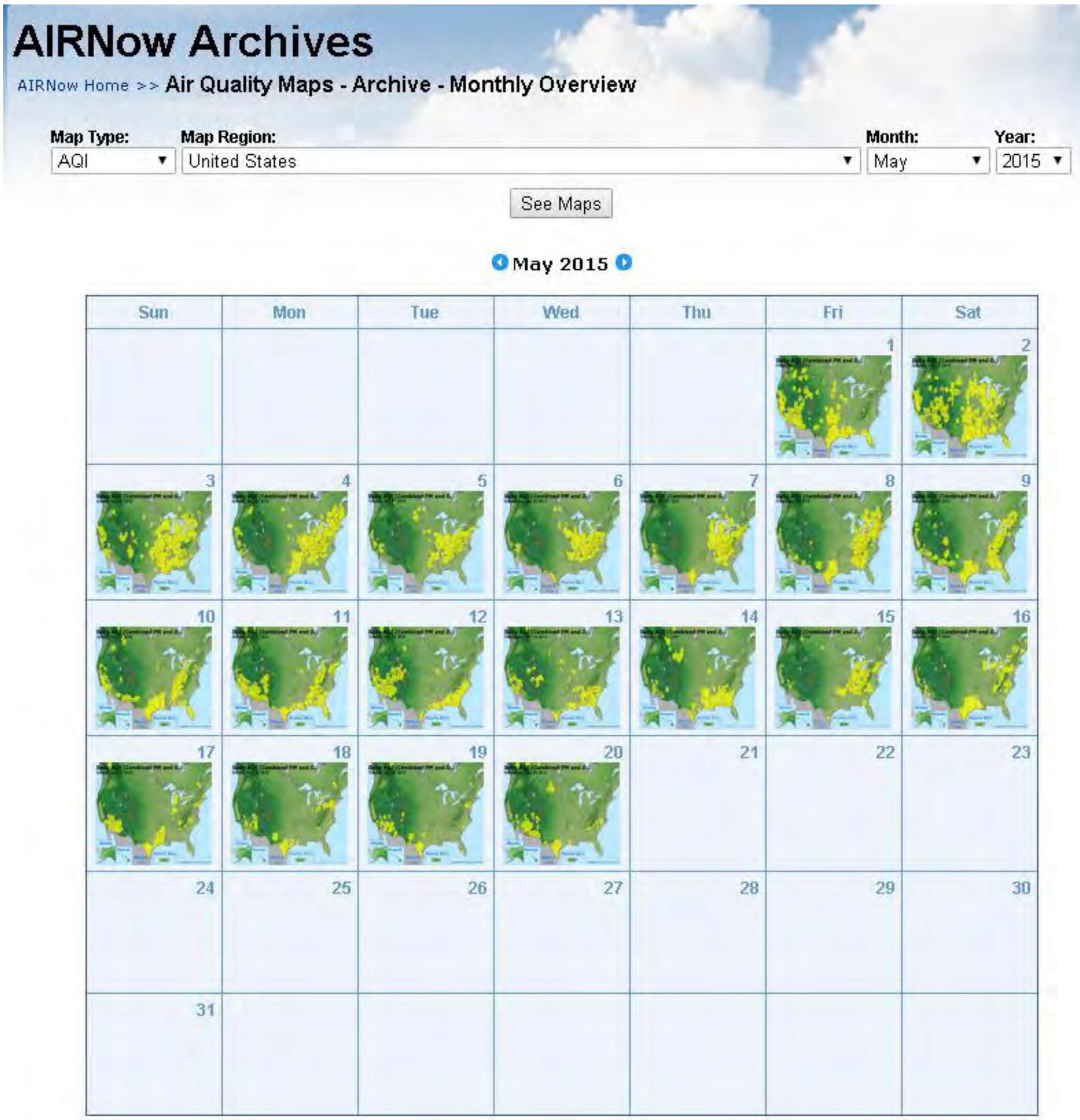
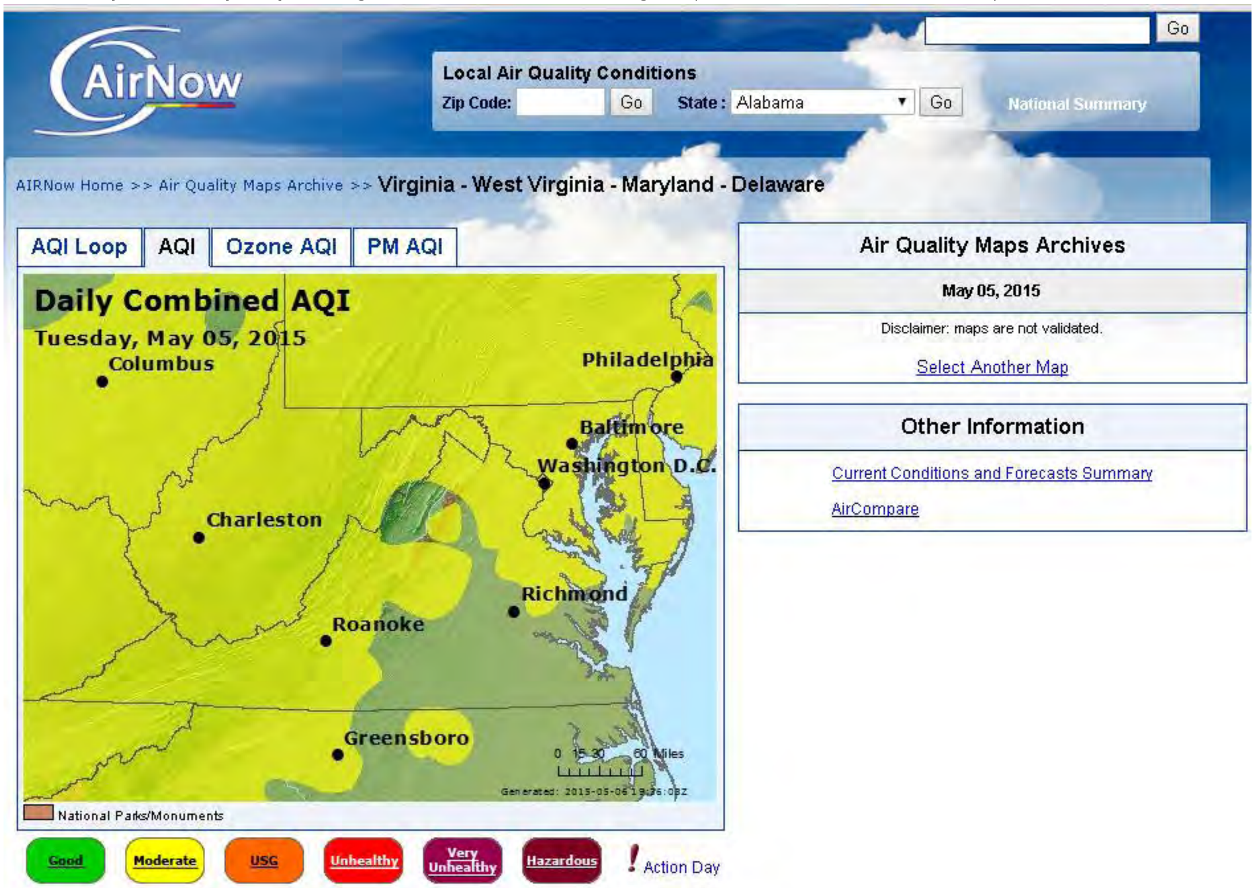


Figure 9: Regional map *of Virginia, West Virginia, Maryland, and Delaware on May 5, 2015. This provides an example of air quality throughout the Mid Atlantic Region (Source: AirNow.com, 2015).*



4.2.4. Shrink-swell Soils

Various areas of the Middle Peninsula have expandable soils that may have the potential to shrink and /or swell with changes in moisture content. The sensitivity of a soil to shrink or swell is related to the amount of clay minerals in the soil. These soils are very affected by changes in moisture content. They have a high tendency to expand (swell) when receiving a lot of moisture and contract (shrink) during times of little or no precipitation. Soils that have a high shrink-swell rating may cause damage to buildings, roads, or other structures if not compensated for by engineering. Special design is often needed for construction in such soils.

House Joint Resolution No. 243 (passed by the Virginia House of Delegates and Senate in March 1996) requires mandatory education for Virginia building code officials on the issue of expansive soils. Where expansive or other problem soils are identified, various methods for responding to them are permitted, including removal and replacement of soils, stabilization by dewatering or other means, or the construction of special footings, foundations, or slabs on how to deal with such soil conditions. This mandatory education is intended to provide guidance on the type of construction techniques to be employed where problem soils are present. While not preventing a site from being used, a high shrink-swell capability places a potential restriction on the size and weight of the building that may be built upon it.

Shrink-swell soils are not specifically addressed in the Essex County Comprehensive Plan (1998 & 2014 draft), however soils associations are generally described. The Rappahannock-Molena-Pamunkey soil association is located on tidal marshes along the Rappahannock River and along floodplain of major creeks that feed into the River. The soil association is predominately Rappahannock soils, which are not suitable for any type of development because of flooding, high water table, and high organic content. These soils are very poorly drained with a surface layer of loam and subsurface of loam, fine sandy loam, and clay loam. About half of the land within this soil association is farmed; the rest is tidal and freshwater marshes. Some areas are used for waterfront development, but seasonal wetness, flooding, and unsuitability for septic systems limits the uses of this land. The suitability of the soil for septic systems and for agriculture is a prime consideration in making general land use policy decisions in Essex County.

Some of the area of the Town of Tappahannock is also on soils of the Rappahannock-Molena-Pamunkey soil association, primarily along Hoskin's Creek and Tickner's Creek (Town of Tappahannock Comprehensive Plan, 1991). These areas are not suitable for development, therefore eliminating potential problems associated with structures built on shrink-swell soils.

Shrink-swell soils are not specifically addressed in the Gloucester County Comprehensive Plan (amended 2001). However, in an analysis of soil suitability for development, clayey soils account for roughly 6,600 acres, or approximately 5% of the area of the county. Because these conditions are often coincident with shrink-swell soils, this is an approximate estimation of shrink-swell soil conditions within the county. These clayey soils are also listed as being unsuited for housing septic systems. The Gloucester County Land Use Plan generally coordinates the Bayside Conservation District and Resource Conservation District with large areas of soils unsuitable for septic tank use or otherwise unsuitable for high density or commercial development due to physical constraints. Shrink-swell soils are also not addressed in the King and Queen County Comprehensive Plan (1994).

Only one area in King William County (Bohicket) is rated high for shrink-swell soils (King William Comprehensive Plan 2003). According to the Comprehensive Plan, the County uses the Soil Survey results in formulating future land use policies. Goals and implementation strategies within the County's Comprehensive Plan include increasing public awareness of potential problems resulting from building on soils with moderate to high shrink-swell characteristics, discouraging development in areas that are unsuited for development because of soil conditions, continue policies that require soil feasibility studies prior to approval of residential rezonings, include in the plan review process a requirement for evaluating shrink-swell soil qualities, and provide builders and developers with advice and information on shrink-swell qualities of soils and the need to evaluate these conditions before committing to construction. Shrink-Swell soils are not addressed in the Town of West Point's Comprehensive Plan (1994).

High shrink-swell soils are present in the northeastern tip of Mathews County and along the waterfront of the rivers and streams. Most of the wetlands in the County and most of the areas within the Chesapeake Bay Resource Protection Areas (protected from development by the Chesapeake Bay Preservation Act, adopted by the Virginia General Assembly in 1988) are shrink-swell soils. These soils account for just a little more than 7,000 acres of Mathews County.

According to the Middlesex County Comprehensive Plan (2001), shrink-swell soils within Middlesex County limit community development in the Ackwater, Craven, and Slagle soil series. Together, the lands comprised of these soils make up approximately 12,350 acres, or roughly 15% of the area of the county. Community development in these areas is restricted because the limitations caused by these soils cannot normally be overcome without exceptional, complex, or costly measures.

Only low to moderate shrink-swell soil potential exists in the Town of Urbanna, leaving the soils of the Town generally moderately suited for development (Town of Urbanna Comprehensive Plan, amended

1995). The Town's Comprehensive Plan states that individual sites should be examined in detail prior to any development.

4.2.5. Landslides

Similar to karst, Figure 10 shows that most landslide hazards are located in western and southwestern Virginia. The term "landslide" is used to describe the downward and outward movement of slope-forming materials reacting under the force of gravity. The term covers a broad category of events, including mudflows, mudslides, debris flows, rock falls, rock slides, debris avalanches, debris slides, and earth flows. These terms vary by the amount of water in the materials that are moving.

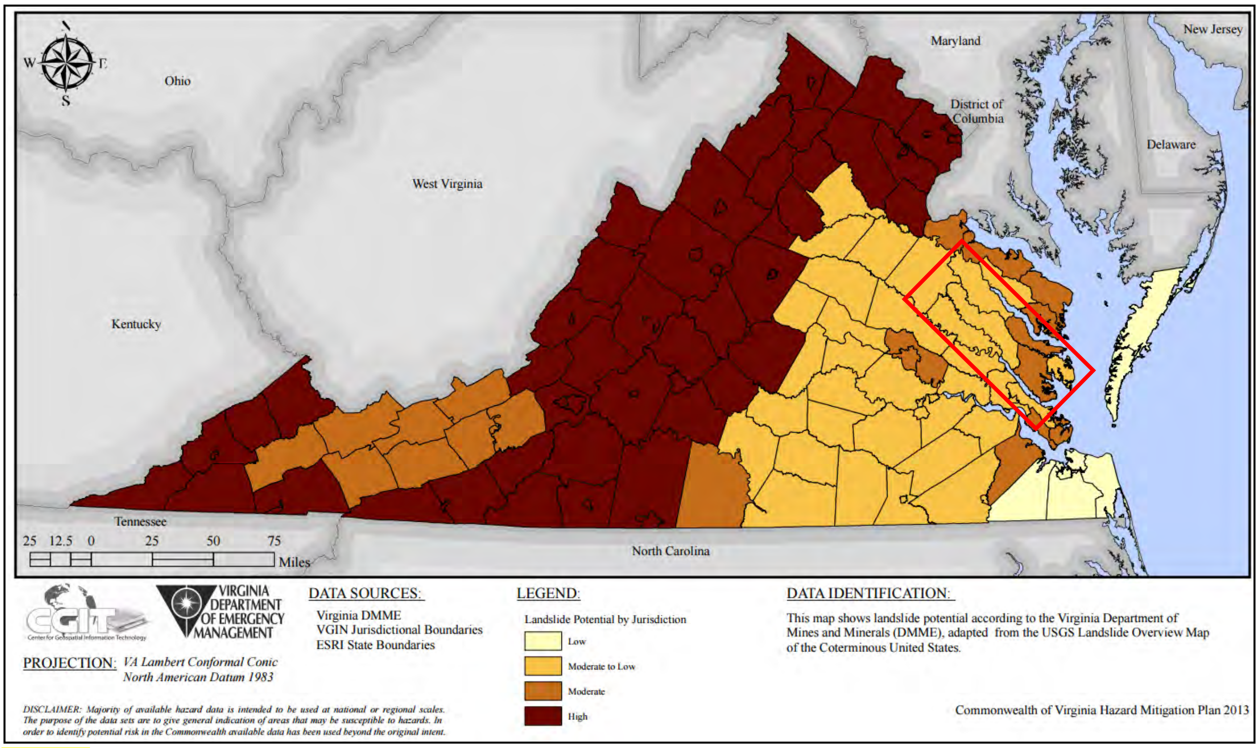


Figure 10: Landslide Potential *as assessed by VDEM. Middle Peninsula localities have a potential of landslides ranging from Moderate or Low to Moderate. The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

Several natural and human factors may contribute to or influence landslides. How these factors interrelate is important in understanding the hazard. The three principal natural factors are topography, geology, and precipitation. The principle human activities are cut-and-fill construction for highways, construction of buildings and railroads, and mining operations. Landslides can cause serious damage to highways, buildings, homes, and other structures that support a wide range of economies and activities. Landslides commonly coincide with other natural disasters. Expansion of urban development contributes to greater risk of damage by landslides.

As depicted in Figure 11, the majority of the Middle Peninsula region, with the exception of a small area in King William, has a low susceptibility to landslides and a low to moderate previous incidence.

Landslide Impact (Extent)

The USGS divides landslide risk into six categories. These six categories were grouped into three, broader categories to be used for the risk analysis and ranking; geographic extent is based off of these groupings. The categories include:

High Risk

1. High susceptibility to landsliding and moderate incidence.
2. High susceptibility to landsliding and low incidence.
3. High landslide incidence (more than 15% of the area is involved in landsliding).

Moderate Risk

4. Moderate susceptibility to landsliding and low incidence.
5. Moderate landslide incidence (1.5 - 15% of the area is involved in landsliding).

Low Risk

6. Low landslide incidence (less than 1.5 % of the area is involved in landsliding).

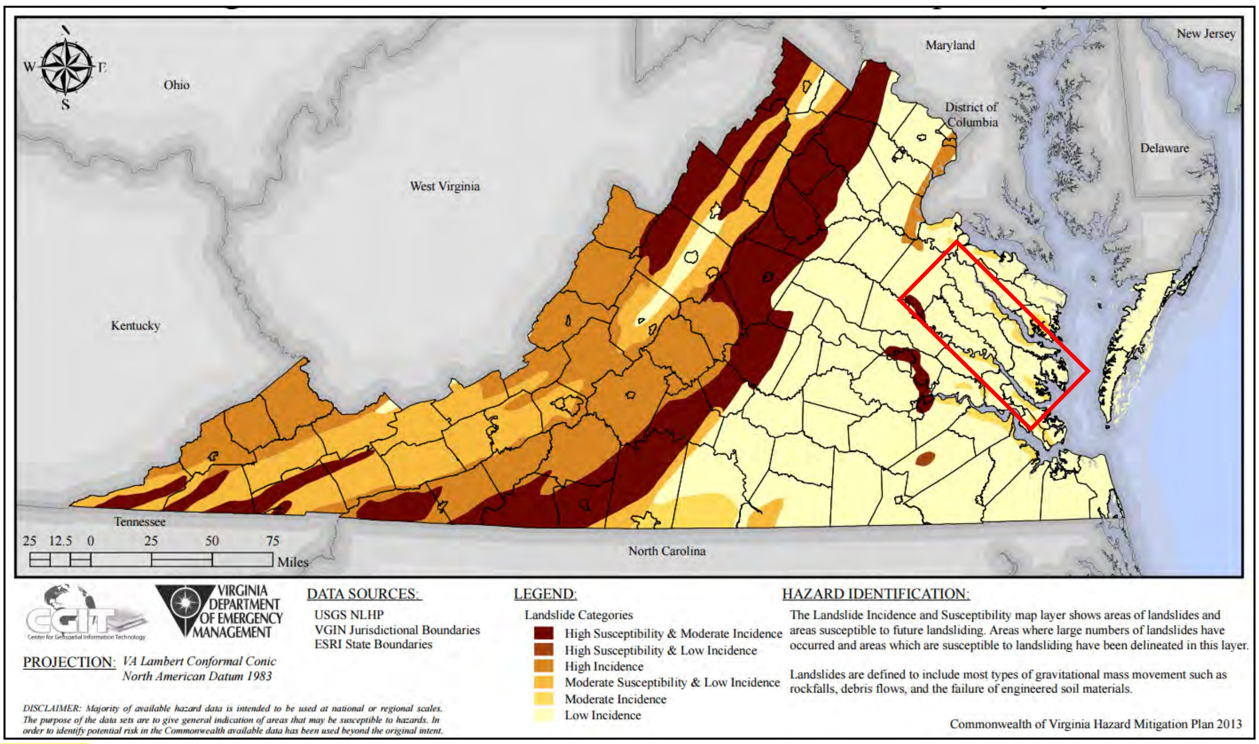


Figure 11: Landslide Incidence and Susceptibility. *The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

4.2.5. Land Subsidence/Karst

Land subsidence is the lowering of surface elevations due to changes made underground. The USGS notes that land subsidence is usually caused by human activity such as pumping of water, oil, or gas from underground reservoirs. Land subsidence often occurs in regions with mildly acidic groundwater and the geology is dominated by limestone, dolostone, marble or gypsum. Karst is the term used to refer to geology dominated by limestone and similar soluble rocks. The acidic groundwater dissolves the surrounding geology creating sinkholes. Sinkholes are classified as natural depressions of the land surface. Areas with large amounts of karst are characterized by the presence of sinkholes, sinking streams, springs, caves and solution valleys. These conditions do not occur in the Middle Peninsula (Figure 12).

Landslide Subsidence – Karst (Impact)
Since the Middle Peninsula region does not have karst, the potential hazard of land subsidence due to karst is absent.

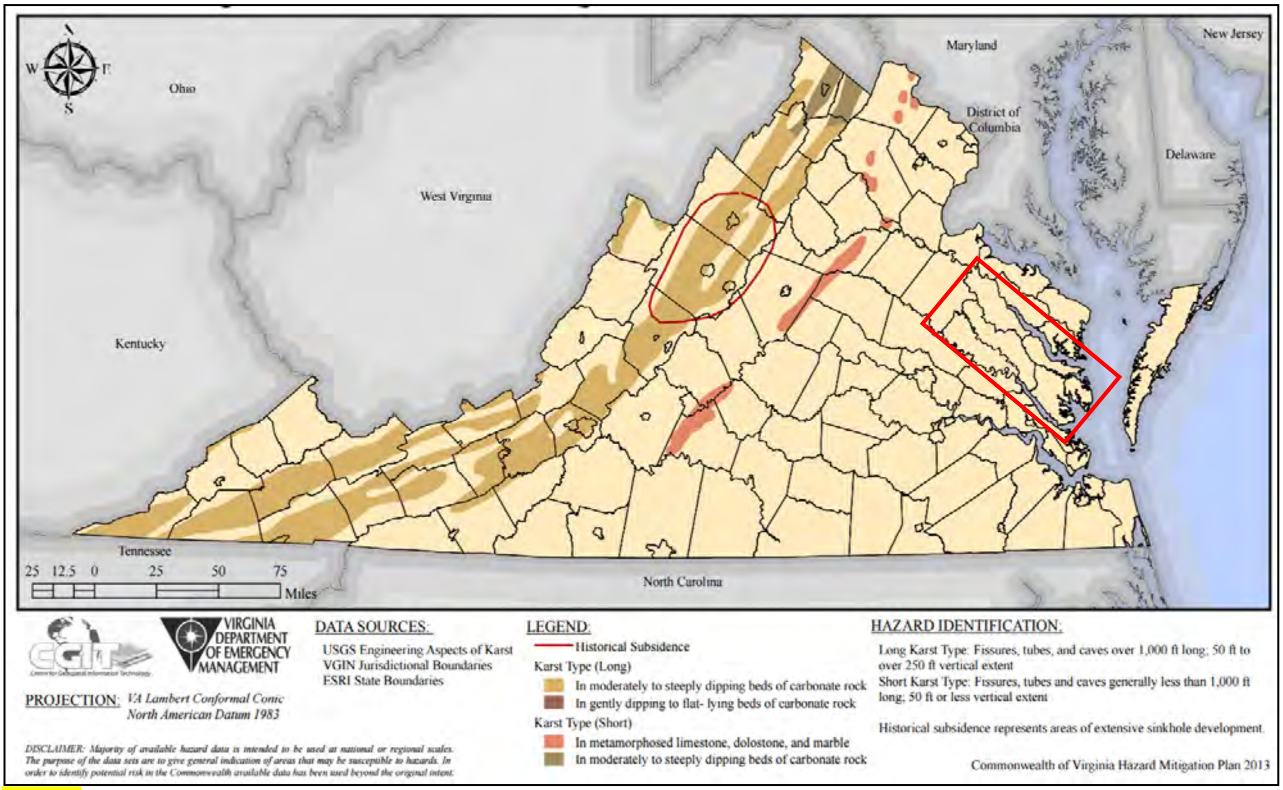


Figure 12: Karst regions and Historical Subsidence *are primarily limited to the mountainous regions of the state. The area encompassing the Middle Peninsula is highlighted on the map with a red square. (Source: Commonwealth of Virginia Hazard Mitigation Plan, 2013)*

4.2.7. Tsunami
A tsunami is a wave, or series of waves, generated in a body of water by a disturbance that vertically displaces (moves up or down) the water column. Earthquakes, landslides, explosions, volcanic eruptions, and meteorites can generate tsunamis (Musick 2005). Earthquakes can cause tsunamis when large areas of the sea floor move and vertically displace the overlying water. If the sea floor movement is horizontal, a tsunami is not generated. After a large-scale vertical sea-floor movement, waves are formed when the displaced water mass travels across the surface of the ocean.

Tsunamis along the east coast of the United States are extremely unlikely. However, geologists Steven N. Ward and Simon Day (2001) describe a landslide that could cause a collapse of a massive piece of the west flank of Cumbre Vieja Volcano on La Palma Island in the Canary Islands (off the western coast of Africa) into the Atlantic Ocean. This could generate tsunami waves that arrive on the coasts of the Americas as much as 70 ft in height. The scientists used modeling techniques to produce their conclusion of this "worst case scenario". The Cumbre Vieja Volcano last erupted in 1949 and shows no signs of activity.

4.2.8. Volcanoes
The United States ranks third, behind Indonesia and Japan, in the number of historically active volcanoes. In addition, about 10 percent of the more than 1,500 volcanoes that have erupted in the past 10,000 years are

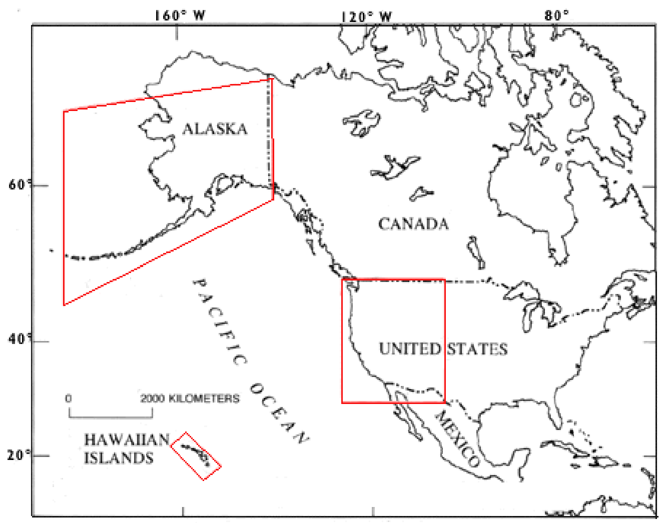


Figure 13: Map of United States showing areas where active volcanoes are located *(image courtesy USGS).*

located in the United States (Brantley 1997). Most of these volcanoes are found in the Aleutian Islands, the Alaska Peninsula, the Hawaiian Islands, and the Cascade Range of the Pacific Northwest; the remainders are widely distributed in the western part of the Nation (Figure 12).

Volcanoes are considered hazardous because of the dangers associated with pyroclastic flows emitted from them during an eruption (USGS 1999). Pyroclastic flows are high-density mixtures of hot, dry rock fragments and hot gases that move away from the vent that erupted them at high speeds. They may result from the explosive eruption of molten or solid rock fragments, or both. They may also result from the non-explosive eruption of lava when parts of dome or a thick lava flow collapses down a steep slope. A pyroclastic flow will destroy nearly everything in its path. With rock fragments ranging in size from ash to boulders traveling across the ground at speeds typically greater than 80 km per hour, pyroclastic flows knock down, shatter, bury or carry away nearly all objects and structures in their way. The extreme temperatures of rocks and gas inside pyroclastic flows, generally between 200°C and 700°C, can cause combustible material to burn, especially petroleum products, wood, vegetation, and houses. The Eastern United States does not have any active volcanoes; therefore, pyroclastic flows are not considered a critical hazard to the Middle Peninsula.

4.3. Hazards considered "Moderately-Critical" Hazards to the Middle Peninsula

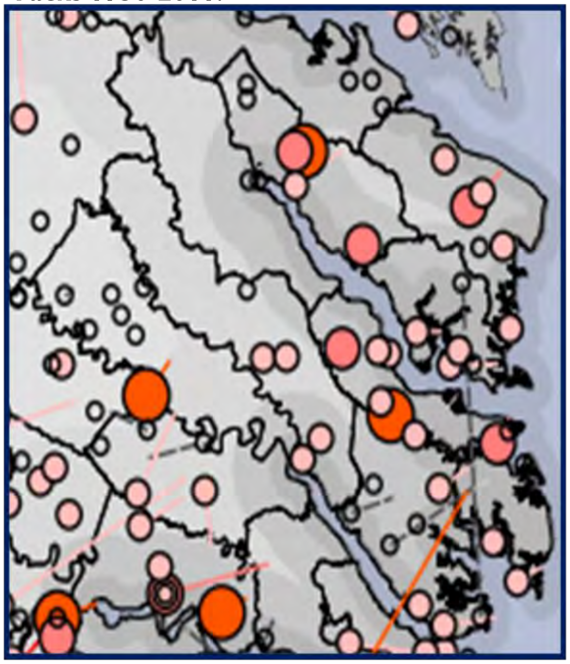
The following sections describe natural hazards that have historically occurred in the Middle Peninsula, yet ranked lower than the Critical Hazards in terms of risk during hazard prioritization. These hazards were deemed "Moderately-Critical Hazards" to the Middle Peninsula region by the RAMP Steering Committee.

4.3.1 Tornadoes

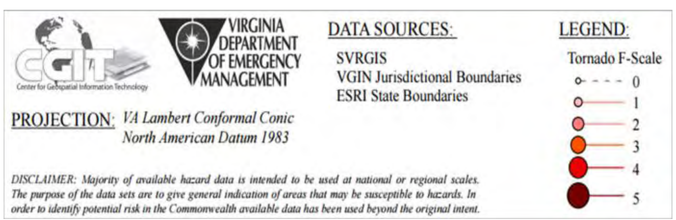
The National Weather Service (NWS) defines a tornado as a violently rotating column of air in contact with the ground and extending from the base of a thunderstorm. A condensation funnel does not need to reach to the ground for a tornado to be present; however a debris cloud beneath a thunderstorm is all that is needed to confirm the presence of a tornado, even without a condensation funnel. Tornadoes are distinguishable from waterspouts, which are small, relatively weak rotating columns of air over water beneath a cumulonimbus or towering cumulus cloud. Waterspouts are most common over tropical or subtropical waters. The exact definition of waterspout is debatable. In most cases the term is reserved for small vortices over water that are not associated with storm-scale rotation (i.e., they are the water-based equivalent of landspouts). Yet there is sufficient justification for calling virtually any rotating column of air a waterspout if it is in contact with a water surface.

Tornadoes often appear as a funnel shaped cloud or a spiraling column of debris extending from storm clouds to the ground. They are created during severe weather events like thunderstorms and hurricanes when cold air overrides a layer of warm air, causing the warm air to rise rapidly. Tornadoes may be only several yards across, or in rare cases, over a mile wide. Winds within a tornado can reach speeds over 250 mph, but most tornado winds are 100 mph or less. Weak tornadoes (categorized as F0 and F1 on the Fujita

Figure 14: Historic Tornado Touchdowns and Tacks 1950-2011.



HAZARD IDENFICATION: Historic tornado touchdowns and tracks are symbolized for visual effect and are not drawn to scale. Actual tornado swath widths vary considerably, although more intense tornadoes are generally wider.



scale, Table 10 & 11) are most common on the Middle Peninsula and often last only a minute before dissipating. From 1950 through the year 2014, 673 tornadoes were documented in Virginia (Tornado History Project, 2015). Within Middle Peninsula localities 38 tornadoes that touched down between1950 to 2014 (See Appendix __). While the most tornadoes touched down in the Middle Peninsula during April, July is considered the most active month for tornadoes in Virginia. The hot, humid days common to July are often accompanied by a late afternoon or evening thunderstorm.

The hot temperatures and humidity of the late afternoon fuel the thunderstorm's growth. If certain conditions are right, a tornado may develop. Hurricane-induced tornadic activity can also occur close to the coastline as a hurricane makes landfall (Watson 2002). Virginia's tidewater counties see a fair number of tornadoes for two reasons, both of which are related to the region's proximity to Chesapeake Bay and the coast. For instance, as waterspouts are common they will occasionally come onshore and do some damage. Once the waterspout comes onshore, it is considered a tornado and is generally classified as a F0. The second instance this area sees an increase in tornadoes is that often during the warm months there is a bay breeze or sea breeze front (bay or sea cooled air on one side of the front and land heated air on the other). When a large rotating thunderstorm moves over a boundary/front such as this, there is an increased chance that conditions will be right for the development of a tornado (Watson 2002). Between 1950 and 2014, twelve tornadoes were reported in Gloucester County, seven in Middlesex, seven in Mathews, six in King and Queen County, two in Essex County, and seven in King William County (NCDC Storm Event Database). The Virginia State Hazard Plan illustration above shows historic tornado touchdowns within the Middle Peninsula (Figure 14). While the historic data appears to show that the Middle Peninsula has a low annual probability of being struck by a tornado, it is important to note that because tornadoes can result from severe thunderstorms and hurricanes, the susceptibility of this region to these storms carries the threat of tornadoes along with it.

Tornado Vulnerability

Weak tornadoes may break branches or damage signs. Damage to buildings (ie. mobile homes or weak structures) primarily affects roofs and windows, and may include loss of the entire roof or just part of the roof covering and sheathing. Windows are usually broken from windborne debris.

In a strong tornado, some buildings may be destroyed but most suffer damage like loss of exterior walls or roof or both; interior walls usually survive.

Violent tornadoes cause severe to incredible damage, including heavy cars lifted off the ground and thrown and strong frame houses leveled off foundations and swept away; trees are uprooted, debarked and splintered.

Weak tornadoes make up 74% of all tornadoes, while 67% of all tornado deaths come from violent tornadoes.

Tornado Extent (Impact)
In Virginia, tornadoes primarily occur from April through September, although tornadoes have been observed in every month. Low-intensity tornadoes occur most frequently; tornadoes rated F2 or higher are very rare in Virginia, although F2, F3, and a few F4 storms have been observed. In comparison to other states, Virginia ranks 28th in terms of the number of tornado touchdowns reported between 1950 and 2006; Midwestern and Southern states ranked significantly higher.

Table 10: Fujita Scale to measure tornados.

F #	Est. Wind (mph)	Typical Damage
F0	< 73	Light: chimneys damaged, shallow-rooted trees pushed over
F1	73-112	Moderate: mobile homes pushed off foundations, cars blown
F2	113-157	Considerable: mobile homes demolished, trees uprooted, roofs torn off frame houses
F3	158-206	Severe: roof and walls torn down, trains overturned, cars thrown
F4	207-260	Devastating: well-constructed walls leveled, large objects thrown
F5	261-318	Incredible: homes lifted and carried, cars thrown 300 ft, trees de-barked

Table 11: Fijita Scale, Derived Enhanced Fujita (EF) Scale and Operated EF Scale.

Fujita Scale			Derived EF Scale		Operational EF Scale	
F #	Fastest ¼ mile (mph)	3 Second Gust (mph)	EF #	3 Second Gust (mph)	EF #	3 Second Gust (mph)
0	40-72	45-78	0	65-85	0	65-85
1	73-112	79-117	1	86-109	1	86-110
2	113-157	118-161	2	110-137	2	111-135
3	158-207	162-209	3	138-167	3	136-165
4	208-260	210-261	4	168-199	4	166-200
5	261-318	262-317	5	200-234	5	Over 200

4.3.2. Snow Storm
The winter months can bring a wide variety of natural hazards to the Middle Peninsula, including blizzards, snowstorms, ice, sleet, freezing rain, and extremely cold temperatures. All of these weather events can be experienced throughout the state, depending on the depth of cold air that is in place over the region when the storm event comes. The Middle Peninsula's biggest winter weather threats come from Northeasters or Nor'easters. These large storms form along the southern Atlantic coast and move northeast into Virginia along the Mid-Altlantic coast. These events are explained in detail in the following section describing Critical Hazards to the Middle Peninsula, under the sub-heading "Winter Ice Storms". Winter

storm events can bring strong winds and anything from rain to ice to snow to even blizzard conditions over a very large area. This combination of heavy frozen precipitation and winds can be quite destructive and lead to widespread utility failures and high cleanup costs. Nor'easters may occur from November through April, but are usually at their worst in January, February, and March.

The impacts of winter storms are minimal in terms of property damage and long-term effects. The most notable impact from winter storms is the damage to power distribution networks and utilities. Severe winter storms with significant snow accumulation have the potential to inhibit normal functions of the Middle Peninsula. Governmental costs for this type of event are a result of the needed personnel and equipment for clearing streets. Private sector losses are attributed to lost work when employees are unable to travel. Homes and businesses suffer damage when electric service is interrupted for long periods. Health threats can become severe when frozen precipitation makes roadways and walkways very slippery and due to prolonged power outages and if fuel supplies are jeopardized. Occasionally, buildings may be damaged when snow loads exceed the design capacity of their roofs or when trees fall due to excessive ice accumulation on branches. The primary impact of excessive cold is increased potential for frostbite, and potentially death as a result of over-exposure to extreme cold. Some secondary hazards extreme/excessive cold present is a danger to livestock and pets, and frozen water pipes in homes and businesses.

Snowstorms do not occur every year in the Middle Peninsula. The West Virginia University Extension Service developed estimates the likelihood for snowfall frequency and accumulation for 152 monitoring stations across the Commonwealth based on historic snowfall accumulation and frequency data (Rayburn and Lozier 2001, these data are available on-line at: http://www.wvu.edu/~agexten/forglvst/VAsnow/index.htm). Three of these stations are located on the Middle Peninsula: Urbanna in Middlesex County, Walkerton in King and Queen County, and West Point in King William County. While the other counties of the Middle Peninsula were not included in the West Virginia University Extension Office data, these stations may be considered representative to predict annual snow cover likelihood for the rest of the Middle Peninsula.

At the Urbanna Station in Middlesex County, snow cover data was collected for 24 years between 1949 and 1973 (*Appendix* #. Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50% risk of having between 1 and 8 inches of snow on the ground for 8 days or more. This means that, in one (1) year out of two (2), Urbanna will probably have snow of up to 8 inches on the ground for 8 days. In one (1) year out of four (4), Urbanna may have snow cover up to 8 inches deep for 12 days (in other words, there is a 25% chance of having snow for 12 days). In one year out of ten, Urbanna may have up to 8 inches of snow for 17 days (there is a 10% chance of having snow for 17 days). For deeper accumulations (greater than 8 inches), there is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days.

At the Walkerton Station in King and Queen County, snow cover data was collected for 66 years between 1931 and 1997 (*Appendix* #). Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50% risk of having between 1 and 8 inches of snow on the ground for 6 days or more. This means that, in one year out of two, Walkerton will probably have snow of up to 8 inches on the ground for 6 days. In one year out of 4, Walkerton may have snow cover up to 8 inches deep for 13 days (in other words, there is a 25% chance of having snow for 13 days). In one year out of ten, Walkerton may have up to 8 inches of snow for 22 days (there is a 10% chance of having snow for 22 days). For deeper accumulations (greater than 8 inches), the risk is the same as reported for Urbanna and there is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days. The average annual snowfall for 2014 at the Walkerton Station was 10.0 inches.

At the West Point station in King William County, snow cover data was collected for 44 years between 1953 and 1997 (Appendix #). Based on snowfall frequency and accumulation during this period, a general risk of snow cover and snow depth in a given year was calculated. Rayburn and Lozier determined that there is a 50% risk of having between 1 and 8 inches of snow on the ground for 8 days or more. This means that, in one year out of two, West Point will probably have snow of up to 8 inches on the ground for 8 days. In one year out of 4, West Point may have snow cover up to 8 inches deep for 15 days (in other words, there is a 25% chance of having snow for 15 days). In one year out of ten, West Point may have up to 8 inches of snow for 19 days (there is a 10% chance of having snow for 19 days). For deeper accumulations (greater than 8 inches), the risk is the same as reported for both Urbanna and Walkerton. There is a 10% risk of having snow cover for 2 days or more. This means that, in 1 year out of 10, this location probably will have snow cover of at least 8 inches for 2 days. The average annual snowfall for 2014 at the West Point Station was 10.1 inches.

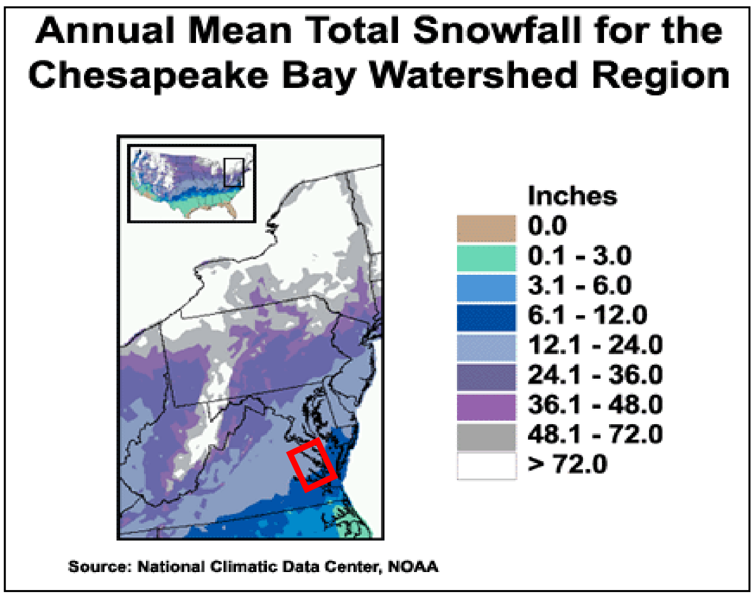


Figure15: Map of annual mean total snowfall for the Chesapeake Bay Watershed region *(StormCenter Communicatons 2003). The area encompassing the Middle Peninsula is highlighted on the map with a red square.*

Compared to western, northern, and mountainous regions of the state, the risk of high snow accumulations in the Middle Peninsula is low (Figure 15). According to the National Climactic Data Center, mean annual snowfall in the Middle Peninsula ranges from between 6 and 12 inches at the lower reaches of the region (primarily in Gloucester and Mathews Counties) to as much as 12 to 24 inches in the upper reaches of the region (primarily in Essex, King and Queen, King William, and Middlesex Counties). The proximity of adjacent water bodies bordering the region (Chesapeake Bay and its tributaries) to the Atlantic Ocean allows the Bay to retain heat and buffer to the region from intense snow. The amount of snow that falls across the watershed varies both from year to year and from location to location. Generally, areas to the north, such as in Pennsylvania and New York, see more snow in an average year than locations in the southern part of the watershed. For areas to the south, such as Norfolk, winters typically pass without a measurable amount of snowfall.

Snow without ice has adverse impacts for the road transportation network, which therefore limits the ability of residents to have access to essential and for some, life-critical emergency medical care.

The ability of the local jurisdictions to provide critical public safety services (ie. fire, emergency medical and law enforcement) could be a focus of any mitigation strategies proposed in the update during the emergency response phase when severe snow events hit the Middle Peninsula.

In December of 2009, a major snowstorm slammed the East Coast and snarled the busy holiday travel season as airports shut down runways, rail service slowed and bus routes were suspended on the last weekend before Christmas. Record snowfall totals were reported at Washington Dulles and Reagan National airports. Accumulation at Dulles reached 16 inches, breaking the old record of 10.6 inches set December, 12, 1964; 13.3 inches was reported at Reagan. The old record there was 11.5 inches set December 17, 1932.

Snowfall Extent (Impact)
The Northeast Snowfall Impact Scale (NESIS) developed by Paul Kocin and Louis Uccellini of the National Weather Service (Kocin and Uccellini, 2004) characterizes and ranks high-impact Northeast snowstorms. These storms have large areas of 10 inch snowfall accumulations and greater. NESIS has five categories: Extreme, Crippling, Major, Significant, and Notable. The index differs from other meteorological indices in that it uses population information in addition to meteorological measurements. Thus NESIS gives an indication of a storm's societal impacts.

NESIS categories, their corresponding NESIS values, and a descriptive adjective:

Category	NESIS Value	Description
1	1—2.499	Notable
2	2.5—3.99	Significant
3	4—5.99	Major
4	6—9.99	Crippling
5	10.0+	Extreme

Winter Weather Section
Since the original plan was developed there has only been one significant snowfall event in the Middle Peninsula. According to the National Climatic Data Center (NCDC), on February 10, 2010 between 1 and 5 inches fell across the region. All of the land area within the region is subject to snowfall. Due to only two operating weather stations in King and Queen and King William Counties, there is little data available for additional analysis. Therefore the information described in the West Virginia Extension Service in the original plan will suffice.

Additional impacts include downed power lines, roof collapses during heavy snow loads, as well as frozen utility lines during extreme cold events.

4.3.3 Coastal/Shoreline Erosion

As flooding is the most frequent and costly natural hazard in the United States - besides fire, nearly 90% of Presidential Disaster Declarations result from natural events where flooding is a major component. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto adjacent floodplains and other low-lying land adjacent to rivers, lakes, ponds and the Chesapeake Bay.

Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall. These conditions are produced by hurricanes during the summer and fall, and nor'easters and other large coastal storms during the winter and spring. Storm surges may overrun barrier islands and push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff.

Thousands of acres of crops and forest lands may be inundated by both saltwater and freshwater. Escape routes, particularly from barrier islands, may be cut off quickly, stranding residents in flooded areas and hampering rescue efforts. Coastal flooding is very dangerous and causes the most severe damage where large waves are driven inland by the wind. These wind driven waves destroy houses, wash away protective dunes, and erode the soil so that the ground level can be lowered by several feet. Because of the coastal nature of the Middle Peninsula, the region is very susceptible to this type of flooding and resulting damage.

Soil Erosion

Hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams in the Middle Peninsula. In addition to the loss of soil along these water bodies, there is damage to man-made shoreline hardening structures such as bulkheads and rap-rap as well as to piers, docks, boat houses and boats due to significant storm surges.

These damages are more severe along the broad open bodies of water on major rivers located closer to the Chesapeake Bay. In general terms, the damage is less intense as you move up the watershed from the southeastern area of the region towards the northwestern end of the Middle Peninsula. Therefore, the soil erosion would is most severe in Mathews, Gloucester and Middlesex Counties and to a lesser degree in the 3 remaining Middle Peninsula Counties of King and Queen, King William and Essex Counties.

The location and the angle at which these hurricanes/nor'easters come ashore region can significantly affect the amount of soil erosion during a particular storm. It can generally be said that hurricane generated soil erosion is uneven in occurrence and that the storm surge affords 2 opportunities for erosion – once as water inundates low-lying amount coast lands and again as floodwaters ebb.

For example with Hurricane Isabel in 2003, its enormous wind field tracked in a north-northwest direction to the west of the Chesapeake Bay with the right front quadrant blowing from the south-southeast. This pushed the storm surge up the Bay and piling it into the western shore – causing serious soil erosion to the eastern land masses in Mathews, Gloucester and Middlesex Counties.

Destructive as it was, Hurricane Isabel might have been worse. If it had been stronger at landfill, the storm surge generated in the Chesapeake Bay may have been higher. Had it stalled along its path and lingered through several tide cycles, prolonged surge conditions, exacerbated by high winds, might have cause more severe erosion. If rainfall has been higher, bank erosion due to slope failure might have been more common, particularly given the wetter than normal months that preceded Hurricane Isabel.

4.3.4. Wildfire

A wildfire is an uncontrolled burning of grasslands, brush, or woodlands. The potential for wildfire depends upon surface fuel characteristics, recent climate conditions, current meteorological conditions, and fire behavior. Hot, dry summers, and dry vegetation increase susceptibility to fire in the fall, a particularly dangerous time of year for wildfire.

The three leading causes of wildfires in Virginia are escaped debris fires, arson, and machine use. Wildfires can also result from natural occurrences, such as lightning strikes. Wildfire danger can vary greatly season to season and is often exacerbated by dry weather conditions.

The VDOF indicates that there are three principle factors that can lead to the formation of wildfire hazards: topography, fuel, and weather. The environmental conditions that exist during spring (March and April) and fall (October and November) exacerbate the hazard. When relative humidity is low and high winds are coupled with a dry forest floor (brush, grasses, leaf litter), wildfires may easily ignite. Years of drought can lead to environmental conditions that promote wildfires. In Virginia, accidental or intentional setting of fires by humans is the largest contributor to wildfires. Residential areas that expand into wildland areas also increase the risk of wildfire threats.

As development has spread into areas which were previously rural, new residents have been relatively unaware of the hazards posed by wildfires and have used highly flammable material for constructing buildings. This has not only increased the threat of loss of life and property, but has also resulted in a greater population of people less prepared to cope with wildfire hazards.

The impacts of wildfires can be widespread leading to many secondary hazards. During a wildfire, the removal of groundcover that serves to stabilize soil can lead to hazards such as landslides, mudslides, and flooding. In addition, the leftover scorched and barren land may take years to recover and the resulting erosion can be problematic.

Because of wild fire risk, the Virginia Department of Forestry (VDOF) has provided new information on identifying high-risk fire areas. Their Fire Risk Assessment Mapping Database was designed to help communities determine areas with the greatest vulnerability to wildfire. Since wildfire occurrence is based on multiple factors, the VDOF developed a fire ranking map to assist to wildfire prevention efforts, as shown in Figure 16. In 2002 and 2003, VDOF examined which factors influence the occurrence and advancement of wildfires and how these factors could be represented in a GIS model. VDOF determined that historical fire incidents, land cover (fuels surrogate), topographic characteristics, population density, and distance to roads were critical variables in a wildfire risk analysis. The resulting high, medium, and low risk category reflect the results of these analyses.

Figure 16: Middle Peninsula Wildfire Risk. *Throughout the region risk to wildlife varies due to historic fire incidents, land cover, topographic, characteristics, population density and distance to roads.*

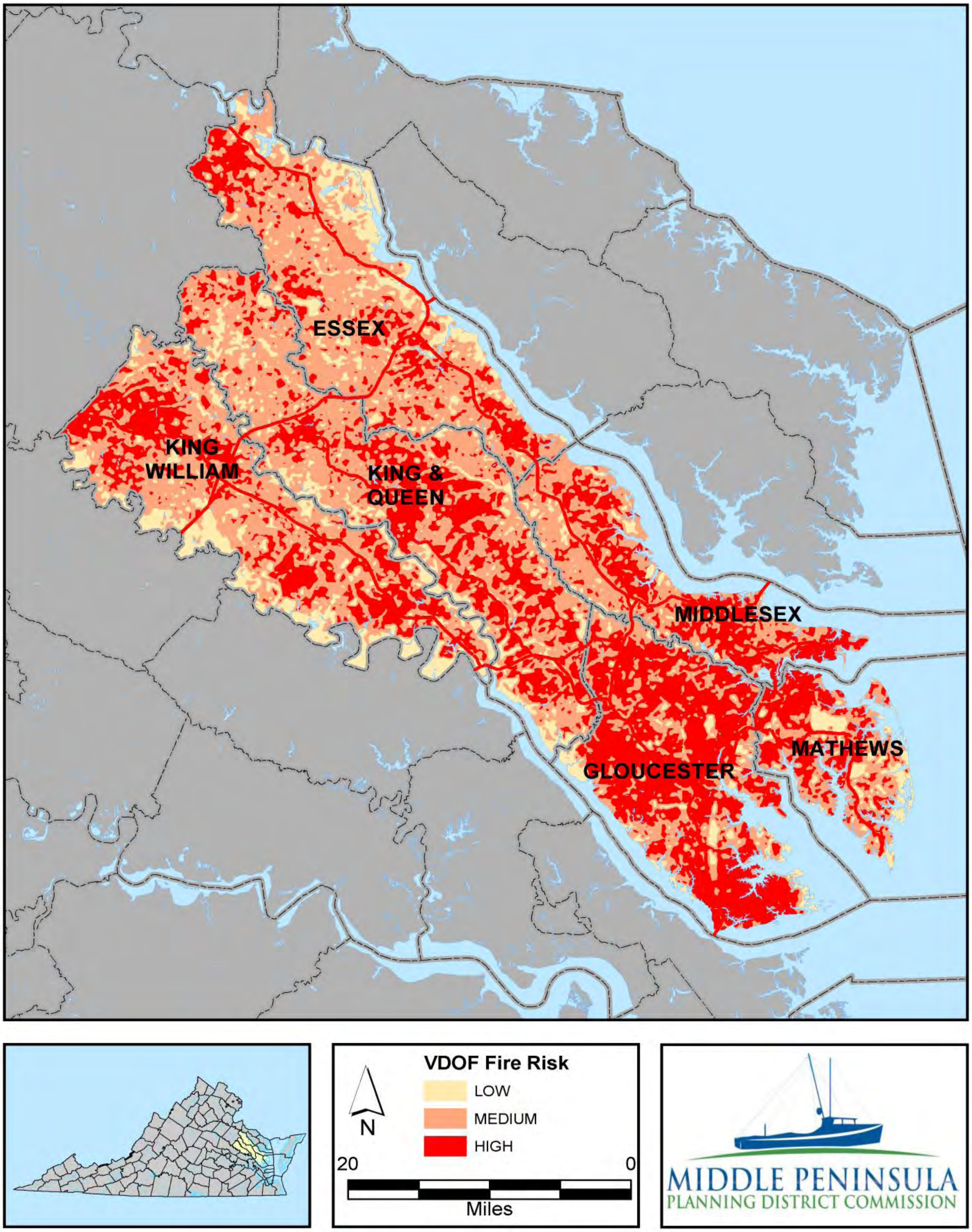


Table 13: Acres of each Middle Peninsula County within each VDOF Fire Risk Category.				
County	**LOW**	**MEDIUM**	**HIGH**	**Total Acreage**
Essex	33,894	105,885	31,999	171,778
Gloucester	16,267	46,195	90,182	152,644
King and Queen	28,569	117,897	59,440	205,906
King William	42,127	89,417	51,039	182,583
Mathews	14,903	28,819	21,966	65,688
Middlesex	8,619	50,251	33,320	92,190
Middle Peninsula Total	144,380	438,464	287,946	870,790

Table 14: Percent of each Middle Peninsula County's area within each VDOF Fire Risk Zone.			
County	**LOW**	**MEDIUM**	**HIGH**
Essex	19.7	61.6	18.6
Gloucester	10.7	30.3	59.1
King and Queen	13.9	57.3	28.9
King William	23.1	49.0	28.0
Mathews	22.7	43.9	33.4
Middlesex	9.3	54.5	36.1
Middle Peninsula Total	**16.6**	**50.4**	**33.1**

As a region, most of the area making up the Middle Peninsula falls within the "Medium" Fire Risk category (Tables 13 and 14). It is noteworthy that nearly 60 percent of the area of Gloucester County falls within the "High" Fire Risk category (Table 14).

Debris burning continues to be the leading cause of forest fires in Virginia. The Commonwealth of Virginia has several laws that help to reduce the risk of wildfires. Most notably is the 'Virginia's 4:00 PM Burning Law', which goes into effect each spring. The 4:00 PM Burning Law is different from the burning bans, which are invoked only during periods of extreme fire danger. Briefly, the 4:00 PM Burning Law states: from February 15 through April 30 of each year, no burning before 4:00 PM is permitted if the fire is in, or within 300 feet of, woodland, brushland or fields containing dry grass or other flammable material.

Since forest fuels cure during the winter months, the danger of fire is higher in early spring than in summer when the forest and grasses are green with new growth. The 4:00 PM Burning Law is an effective tool in the prevention of forest fires.

Areas where homes meet the Wildland are called the Wildland/Urban interface. Flammable forest fuels often surround homes located in the woods. The VDOF suggests the following safety tips to minimize the threat to homes:

- Have a least 30 feet of defensible space surrounding a home. This will reduce the wildfire threat to a home by changing the characteristics of the surround vegetation. Defensible space also allows firefighters room to put out fires.
- Build with fire-resistant exterior construction materials, such as cement, brick, plaster, and stucco and concrete masonry. Double pane glass windows can make a home more resistant to wildfire heat and flames. Roofs should be Class A.
- Use landscaping materials and design to also create defensible space. Remove flammable plants that contain resins, oils and waxes that burn readily. Large, leafy hardwood trees should be pruned so that the lowest branches are at least 6 to 10 feet high to prevent a fire on the ground from spreading up to the treetops.

- Identify a home and neighborhood with legible and clearly marked street names and numbers so emergency vehicles can rapidly find the location of the emergency. Include a driveway that is at least 12 feet wide with a vertical clearance of 15 feet – provide access to emergency apparatus.

The Steering Committee was interested in including locality specific wildfire events since the 2010 plan. The following events were identified:

- During 2009, Middlesex County experienced a major wildfire north of Urbanna between route 602 and US Route 17 near Hilliard Pond.

- During 2008, Gloucester County experienced a significant fire in the Guinea area that burned several acres. While this fire did not require any evacuations it did require mutual aid from other jurisdictions. This fire was coordinated through Abington Volunteer Fire and Rescue.

In 2008, drought conditions combined with strong winds resulted in sporadic wildfires in numerous locations throughout the Middle Peninsula region. Mutual aid assistance between area fire departments, as well as from the VDOF, was widely used during these wildfire events.

As discussed at the PENEX '09 Regional Training Exercise in September 2009, there is a need for more formalized written agreements between some neighboring jurisdictions when it comes to mutual aid assistance. Also, the lack of operable communications between neighboring jurisdictions willing to offer mutual aid to one another, as well as with state forces, is an issue that was also cited in the After-Action-Report from the PENEX '09 Regional Training Exercise. The PENEX '09 exercise covered jurisdictions in both the Middle Peninsula and Northern Neck regions.

Mitigation strategies formalizing MOUs between area fire departments to quickly respond to the adverse effects of the wildfire hazard should be included as part of the MPNHMP update.

Mitigation strategies to improve communication systems between the local jurisdictions and with their state fire-fighting partners should also be proposed with this update.

In addition, the VDOF safety tips - as noted above - lend themselves to a public education mitigation strategy dealing with wildfires and should be included with this update.

4.3.5. Riverine Flooding

A flood is partial or complete inundation of normally dry land areas. *Riverine flooding* is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snowmelt, or ice. This type of flooding is different from *coastal flooding*, which is caused by storm surge and wave action and affects coastal areas, especially those along the beachfront. There are several types of riverine floods, including headwater, backwater, interior drainage, and flash flooding. Flash flooding is characterized by rapid accumulation or runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur because of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

Periodic flooding of lands adjacent to non-tidal rivers and streams is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal water course, some of the above-normal stream flow spills over onto adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of the stream or river. The recurrence interval of a flood is defined as the average time interval, in years, expected to take place between the occurrence of a flood of a particular magnitude and an equal or larger flood. Flood magnitude increases with increasing recurrence interval.

The major rivers of the Middle Peninsula are tidal in nature, serving as estuarine tributaries of the Chesapeake Bay. Flood hazard varies by location and type of flooding. Riverine flooding is more of a threat to mountainous regions, where population areas typically lie in narrow valleys, which lack the ability to store and dissipate large amounts of water. Consequently, stream flow tends to increase rapidly.

Riverine flooding was addressed during the flood mitigation planning process and mitigation strategies in this update will include:

1. Continuing to maintain and enforce a strong NFIP,
2. Investigating the feasibility of undertaking a FEMA-promoted Community Rating System (CRS) for enhanced floodplain protection policies, and
3. Actively promoting public education programs about development in and adjacent to areas with a history of flooding from rivers and creeks.

Riverine Flooding

As riverine flooding is defined as the overflow of rivers, streams, drains, and lakes due to excessive rainfall, rapid snow melt, rapid ice melt or a combination of all three and This type of flooding involves the partial or complete inundation of normally dry land areas. If differs from coastal flooding, which is caused by a combination of rain, storm surge and wave action and affects coastal areas, especially those along the beachfront.

Approximately 60% of Virginia's river flooding begins with flash flooding from tropical systems passing over or near the state. Riverine flooding also occurs because of successive rainstorms. Rainfall from any one storm may not be enough to cause a problem, but with each successive storm's passage over the basin, rivers rise until eventually they overflow their banks. If this occurs in late winter or spring, melting snow in the mountains can produce additional runoff that can compound flooding problems.

There are several types of riverine flooding including headwater, backwater, interior drainage, and flash flooding:

Headwater flooding results from significant rain events that occur at the upper reaches of a watershed that then flow downstream within a short period of time.

Backwater flooding results when the lower portion of a river or stream is blocked by debris or backed up due to a storm surge along the coast.

Interior drainage flooding results when a dam gives way and the water being held in the impoundment is released all at once to the downstream receiving channel.

Flash flooding is characterized by rapid accumulation and runoff of surface waters from any source. This type of flooding impacts smaller rivers, creeks, and streams and can occur because of dams being breached or overtopped. Because flash floods can develop in a matter of hours, most flood-related deaths result from this type of event.

Although flash flooding is more of a threat in the steeper mountainous regions of the state where population areas typically lie in narrow valleys that lack the ability to store and dissipate large amounts of water, some of the hilly areas in the upper reaches of the Middle Peninsula watersheds can experience rapid increase in stream flow resulting in some riverine flooding and subsequent threats to life and property.

Periodic flooding of lands adjacent to non-tidal rivers and streams is a natural and inevitable occurrence. When stream flow exceeds the capacity of the normal water course, some of the above-normal stream flow spills over onto adjacent lands within the floodplain. Riverine flooding is a function of precipitation levels and water runoff volumes within the watershed of the stream or river.

The recurrence interval of a flood is defined as the average time interval, in years, expected to take place between the occurrence of a flood of a particular magnitude and a second one of equal or greater magnitude. Flood magnitude increases with increasing recurrence interval. The interval most referred to and also the basis for many local government regulations is known as the 100-year flood or storm event.

The major rivers in the lower Middle Peninsula are tidal in nature and they serve as estuarine tributaries of the Chesapeake Bay. Flood hazards vary due to the river's location and the type of storm event taking place.

4.3.6. Sea Level Rise

Climate change is an on-going process that is measured over an extended period of time. According to the Intergovernmental Panel on Climate Change, temperatures in Virginia are estimated to increase by 3˚ F in the winter, spring and summer and increase by 4˚F in the fall. Precipitation is estimated to increase by 20% in all seasons by 2100.

The National Wildlife Federation (NWF) predicts that within the Upper Tidewater Region – where the Middle Peninsula is located – sea level will rise 11.2 inches by 2050 and 27.2 inches by 2100.

Temperature, precipitation and wind are considered the 3 direct factors contributing to climate change which can create a number of regional and local impacts, including:

- The frequency and intensity of flooding events may increase.
- Coastal ecosystems may experience increased coastal erosion and risk of pollution due to inundated infrastructure – a result of sea level rise as well as storm events.
- Increased rates of saltwater intrusion into freshwater resources may also occur.
- Loss of near shore habitats and coastal wetlands as sea level rises.
- Access to the roadway network may become limited as the frequency of flooded roads increase due to sea level rise and intense storms. This will increase the maintenance costs for impacted/damaged roads.
- Infrastructure may be impacted if located within floodplains or low lying coastal areas – causing insurance premiums to increase.
- Emergency response units may have to redefine service areas as roads become flooded due to sea level rise and/or storm events.

Overall these anticipated impacts will have greater impacts for the more southern low-lying areas of the Middle Peninsula region and educational/informational mitigation strategies merit consideration with this update.

4.3.7. High Wind / Windstorms (excluding tornados and hurricanes)

High winds and windstorms, when not a result of hurricanes or tornadoes, are often associated with thunderstorms. The NWS defines a severe thunderstorm as having winds 50 kts (58 mph) or hail greater than ¾" in diameter (about dime-sized). A thunderstorm is considered severe if it produces hail larger than 3/4 of an inch (2 cm), winds greater than 58 mph (93 kph), or tornadoes. This strong frontal system could produce violent damaging effects to the community, such as hail, lightning, high winds (sometimes including tornadoes), and flash floods. Numerous thunderstorms occur in Middle Peninsula every year.

The threat that any particular thunderstorm presents varies depending on its intensity, structure, and the ground below it. Many thunderstorms simply require people and their belongings to seek shelter inside a sturdy building. However, severe thunderstorms can be very dangerous and require seeking shelter underground because of the damage, they can cause to buildings. Historically the most severe occur during the spring and summer. In the U.S., only about 10% of all thunderstorms are classified as severe. Seeking shelter before a thunderstorm has arrived is best because high wind and lightning can form well in advance of any precipitation. Hail-resistant roofs can reduce property damage, as can properly attached roofs. As always, learning about what safety measures to take during a thunderstorm is the first and most important step in coping with thunderstorms.

In the U.S., the NWS issues severe thunderstorm watches and warnings. A watch is issued when atmospheric conditions are favorable for the development of a severe thunderstorm. A warning is issued when severe thunderstorms have developed. Similar to tornado watches and warnings, severe thunderstorm warnings are broadcast via media (ie. radio and television), Internet, and NOAA weather radios. Particularly of note for coastal communities, such as the Middle Peninsula, are wind advisories associated with water bodies. A Small Craft Advisory is issued for sustained winds 25-33 knots and/or Seas > 7 feet within 12 hours; There is no legal definition of "small craft" but the Coast Guard generally recommends boats smaller than 33 feet should avoid being on the water, but it depends on the experience of the crew. A Gale Warning is issued for 1-minute sustained surface winds in the range 34 kt (39 mph or 63 kph) to 47 kt (54 mph or 87 kph) inclusive, either predicted or occurring not directly associated with tropical cyclones. Reliable forecasting is essential to providing communities with adequate warnings about incoming thunderstorms and the specific threats that each storm possesses.

Damage from strong winds associated with thunderstorms can result in scattered, but severe damage to buildings and vegetation. Although these severe weather events usually occur during the spring and summer months, the emergency management staff should be prepared for them to occur at any time throughout the year.

Utilizing VDEM-generated information available on their state website and/or other information sources, community preparedness mitigation strategies should be developed by the localities for quick dissemination to their residents. Dissemination outlets should include jurisdictional websites, local radio and TV stations as well as social media sites such as Facebook and twitter.

Derecho

According to the National Weather Service, a derecho is a complex of thunderstorms or a mesoscale convective system (MCS) that produce large swaths of severe, straight-line wind damage at Earth's surface. To be classified as a derecho, the following conditions must be met:

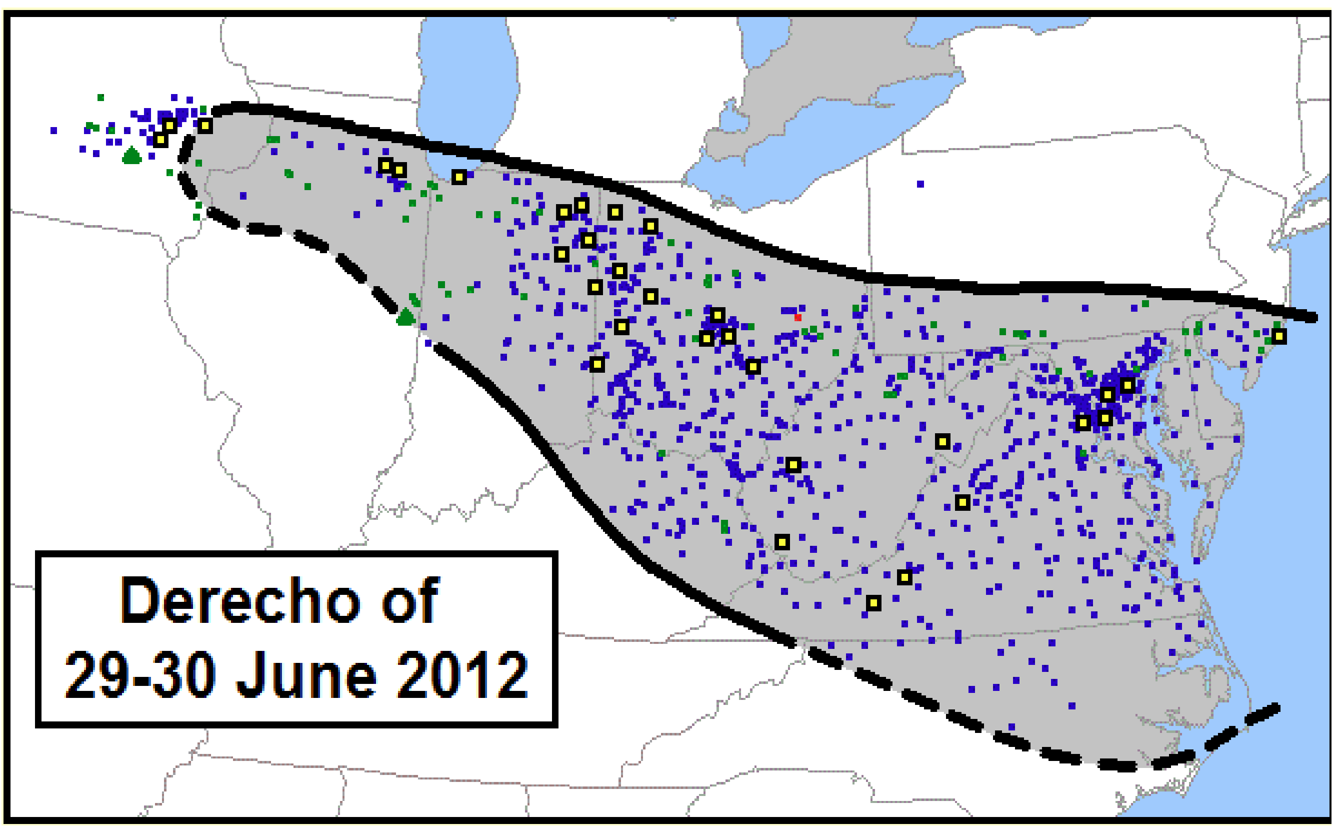
- There must be a concentrated area of convectively induced wind damage or gust greater than or equal to 58 mph occurring over a path length of at least 250 miles.
- Wind reports much show a pattern of chronological progression in either a singular swath (progressive; this event was a classic example) or a series of swaths (serial.

- There must be at least three reports separated by 64 kilometers (km) or more of Enhances Fujita (EFI) damage/or measured convective wind gusts of 74 mph or greater.
- No more than 3 hours can elapse between successive wind damage/gust events.

Derechos can occur year-round but are most common from May to August (Coniglio et al., 2004)

On June 29, 2012, a derecho struck the Ohio Valley and Mid-Atlantic states. The derecho traveled 700 miles, impacting 10 states and Washington, D.C. (Figure 17). The hardest hit states were Ohio, West Virginia, Virginia, and Maryland, as well as Washington, D.C. The winds generated by this system were intense, with several measured gusts exceeding 80 mph. Thirteen people were killed by the extreme winds, mainly by falling trees. An estimated 4 million customers lost power for up to a week. The region impacted by the derecho was also in the midst of a heat wave. The heat, coupled with the loss of power, led to a life-threatening situation. Heat claimed 34 lives in areas without power. The Middle Peninsula experienced wind gusts ≥65 kts (74 mph).

Figure 17: Area affected (black contours) and storm reports (colored symbols) associated with the June, 29, 2012 derecho. *Reports are for the 24-hour period from 7:00 a.m (Central Daylight Time (CDT)) Friday, June 29 to 7:00 a.m. CDT Saturday, June 30. Areal outline based in Iowa and Illinois to reflect the derecho's origin from convection in the region that did not immediately produce continuous derecho-like conditions. In addition, some of the report in those states occurred not with the system here discussed, but rather with a subsequent storm complex that formed on the evening of June 29. The areal outline also is dashed in North Carolina to reflect that many of the damaging wind gusts in the state occurred south of the thunderstorms that produced them. Storm reports depicted as follows. Wind damage or wind gust ≥ 50 kts (59 mph), small blue squares, estimated or measured with gusts ≥65 kts (74 mph), large black squares with yellow centers, hail ≥0.75 inches, small green squares, hail ≥2.0 inches, large green triangles, tornadoes, small red squares (Source: National Weather Service, 2012).*



4.3.8. HAZMAT

HAZMAT can be defined as a material (as flammable or poisonous material) that would be a danger to life or to the environment if released without precautions. Furthermore, a hazardous material is any substance or material in a quantity or form that may pose a reasonable risk to health, the environment, or property. The risk of hazardous material risks include incidents involving substances such as toxic chemicals, fuels, nuclear wastes and/or products, and other radiological and biological or chemical agents. In addition to accidental or incidental releases of hazardous materials due to fixed facility incidents and transportation accidents, regions must be ready to respond to hazmat releases as potential terrorism.

According to VDEM, all jurisdictions in Virginia have a Local Emergency Planning Committee that identified local industrial hazardous materials and keeps the community informed of the potential risks. With a fixed facility, the hazards are pre-identified, and the facility is required to prepare a risk management plan and provide a copy of this plan to local governments.

Hazardous materials carried through Middle Peninsula localities by commercial vehicle may also cause a risk, particularly if the vehicle is involved in an accident. While the vehicle should have placards on the vehicle to identify the hazard on board, however they are less predictable. In accordance with 9VAC20-110 the Virginia Waste Management Board is responsible for promulgating regulations governing the transport of hazardous materials within the Commonwealth. Additionally the VAC also provides requirements for "every person who transports or offers for transportation of hazardous materials within or through the Commonwealth of Virginia" (9VAC20-110-110) Therefore there are measures in place to help reduce the risk of hazards materials being transported through the Middle Peninsula Region.

4.3.9. Ditch Flooding

As per the Commonwealth of DEQ Guidance Memorandum No. 08-2004 Regulation of Ditches under the Virginia Water Protection (VWP) Program, ditch is defined as a linear feature excavated for the purpose of draining or directing surface or groundwater. Ditches may also be constructed to collect groundwater or surface water for the purposes of irrigation.

Throughout the Middle Peninsula of Virginia, the network of aging roadside ditches and outfalls, serving 670 miles of roads, creates the region's primary stormwater conveyance system. Currently each locality in the region experiences inadequate drainage and as a result, roads and private properties are frequently flooded after a storm event. Roadway flooding frequently cuts residents and business off from the county and emergency services for extended periods of time. Flooding has also caused the county school system to be closed due safety concerns. Flooding, risks to public health and safety, property damage, and long-term loss of property use and values are consequences of the inadequate drainage systems, all of which ultimately negatively impact the economy of the Middle Peninsula.

Conditions contributing to the failure of the drainage system, include, but are not limited to, the following:

1. A lack of maintenance, including removal of sediment and overgrown vegetation, causing slopes to be inadequate or reverse slope and/or tides not allowed to recede;
2. Insufficient elevation change (topographic constraints);
3. Cross-culverts are filled with sediment, not adequately maintained, damaged, and/or installed with an inadequate / reverse slope;
4. Unclear ownership and ditch maintenance responsibility (VDOT or private);
5. Sea level rise; and
6. Land subsidence.

When high exposure to hurricanes, nor'easters, tropical storms, sea level rise, and land subsidence is coupled with clogged roadside ditches and outfalls, illicit filling of the ditches on private property, and/or failing ditches, there are significant social, economic, and environmental impacts.

4.4. Hazards Considered "Critical" Hazards to the Middle Peninsula

The following sections describe natural hazards that are common throughout the Middle Peninsula region and deemed "Critical Hazards" to the Middle Peninsula by the Steering Committee.

4.4.1. Winter Ice Storms

Virginia's biggest winter storms are the great "Nor'easters". At times, Nor'easters have become so strong that they have been labeled the "White Hurricane". In order for these storms to form, several things need to occur. High pressure builds over New England. Arctic air flows south from the high center into Virginia. The colder and drier the air is, the denser and heavier it becomes. This cold, dry air is unable to move west over the Appalachian Mountains and it remains trapped to the east side, funneling down the valleys and along the coastal plain toward North Carolina. To the east of the arctic air is the warm water of the Gulf Stream. The contrast of cold air sinking into the Carolinas and the warm air sitting over the Gulf Stream creates a breeding ground for storms. Combine this with the right meteorological conditions such as the position of the jet stream, and storm development may become "explosive" (sudden, rapid intensification; dramatic drop in the central pressure of the storm) (Watson and Sammler 2004) (Figure 15).

Winter Ice Storms occur generally as freezing rain, when precipitation, starts falling as snow, melts as it passes through a warm layer of air several thousand feet above the ground. Beneath the warm layer of air is a shallow layer of freezing air just above the ground. As the liquid precipitation falls through this layer of freezing air, it becomes super-cooled, meaning that its temperature falls below freezing, but it remains a liquid. Before it has a chance to freeze solid (into sleet or ice pellets), the super-cooled liquid droplets hit the ground (or some object such as a tree limb or power line), whose temperature is also below freezing; the water then freezes on contact.

For a good Nor'easter to develop, the jet stream entering the West Coast of the United States splits. The northern branch crosses the northern Rockies and Canada while the southern branch dips to cross the Gulf Coast states, where it picks up a disturbance that it carries northeast across Virginia to rejoin the northern branch over Newfoundland. The northern branch of the jet supports the southward sinking cold air. When this disturbance interacts with the temperature boundary formed by the warm Gulf Stream waters and the arctic air mass inland, a low-pressure system forms. The strong wind from the northeast gives the lowpressure storm its name, *Nor'easter*. Wind blowing counter-clockwise around the storm center carries warm, moist air from the Gulf Stream up and over the cold inland air. The warm air rises and cools, and snow begins. The storm's speed and exact track to the north become critical in properly forecasting and warning for heavy snow across Virginia. On the Middle Peninsula, it is quite common for the rain-snow line to fall right over the northern sections of King William, King and Queen, and Essex Counties. Heavy snow often falls in a narrow 50-mile wide path about 150 miles northwest of the low-pressure center. Closer to the low's center, the warmer ocean air changes the precipitation to sleet, freezing rain and eventually rain. If the forecasted storm track is off by just a little bit, it may mean - 64 - the difference between forecasting heavy rain, freezing rain or sleet, and a foot of snow (Watson and Sammler 2004).

Intense winds around the storm's center build waves that rack the coastline and sometimes drive water inland, causing extensive coastal flooding and severe beach erosion. Unlike a hurricane, which usually comes and goes within one tidal cycle, the Nor'easter can linger through several tides, each one piling more water on shore and into the bays. The March 5-9, 1962 Nor'easter, known as the "Ash Wednesday Storm", lingered off the Virginia Capes for days. It caused over $200 million (in 1962 dollars) in property damage and major coastal erosion from North Carolina to Long Island, N.Y.

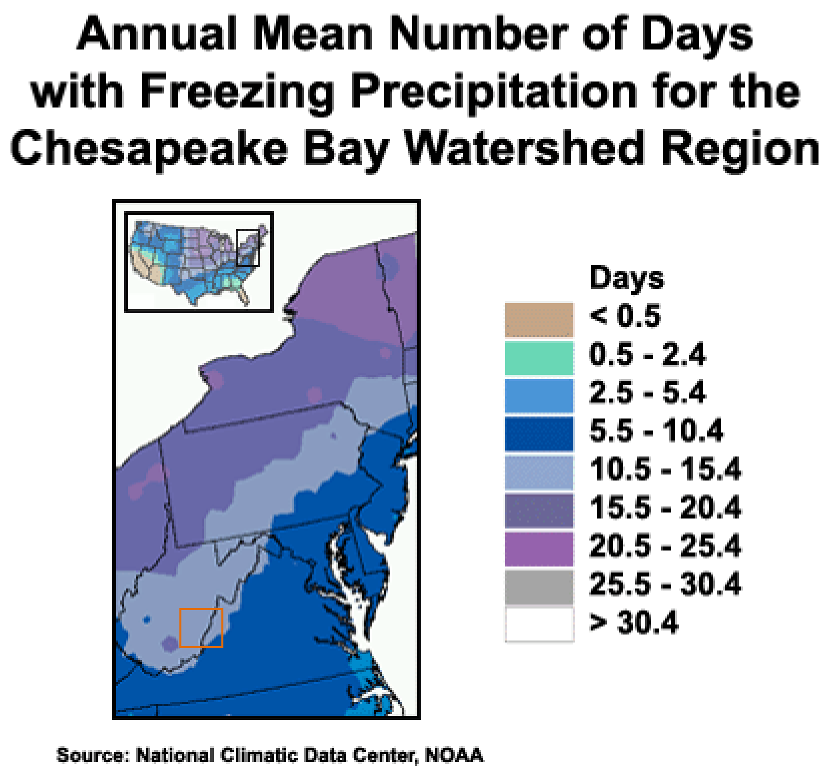


Figure 18: Annual mean number of days with freezing precipitation *(rain or drizzle) for the Chesapeake Bay Watershed region. The area encompassing the Middle Peninsula is highlighted on the map with a red square.*

As with snow, the frequency with which freezing rain occurs varies throughout the Chesapeake Bay watershed. In the northern part of the watershed, around Binghamton, NY, the incidence of freezing rain is one of the highest in the country. Although less common, freezing rain is still a threat even to the southern parts of the watershed. Figure 18 shows how the number of days with freezing precipitation (both rain and drizzle) in an average year varies throughout the Chesapeake Bay region. The Middle Peninsula generally experiences between 5.5 and 10.4 days of freezing rain annually. During the winter of 1993-1994, a series of ice storms struck Virginia. The conditions for the formation of an *ice storm* are not completely unlike those for the formation of a Nor'easter. High pressure over New England funnels cold, dry arctic air south over the state. The air tries to push west but cannot rise over the - 65 - Appalachian Mountains and becomes trapped on the east side. A storm moves northeast from the southern plains or Gulf Coast region. Instead of passing south and east of Virginia, it often moves up the western slopes of the mountains. As this warm, moist air rises over the mountains and the trapped cold air on the east side, precipitation begins (Watson and Sammler, 2004) (Figure 19). The type of precipitation depends on the depth of the cold air. At first the thickness of the 3cold air mass is often enough to produce snow, but as the warm air passes over the cold air and erodes it, the cold air mass gets more and more shallow. Soon the cold air mass is too thin to produce snow. Rain droplets freeze into small ice pellets, or *sleet*, as it falls through the cold air. When sleet hits the ground, it bounces and does not stick to objects (Watson and Sammler 2004).

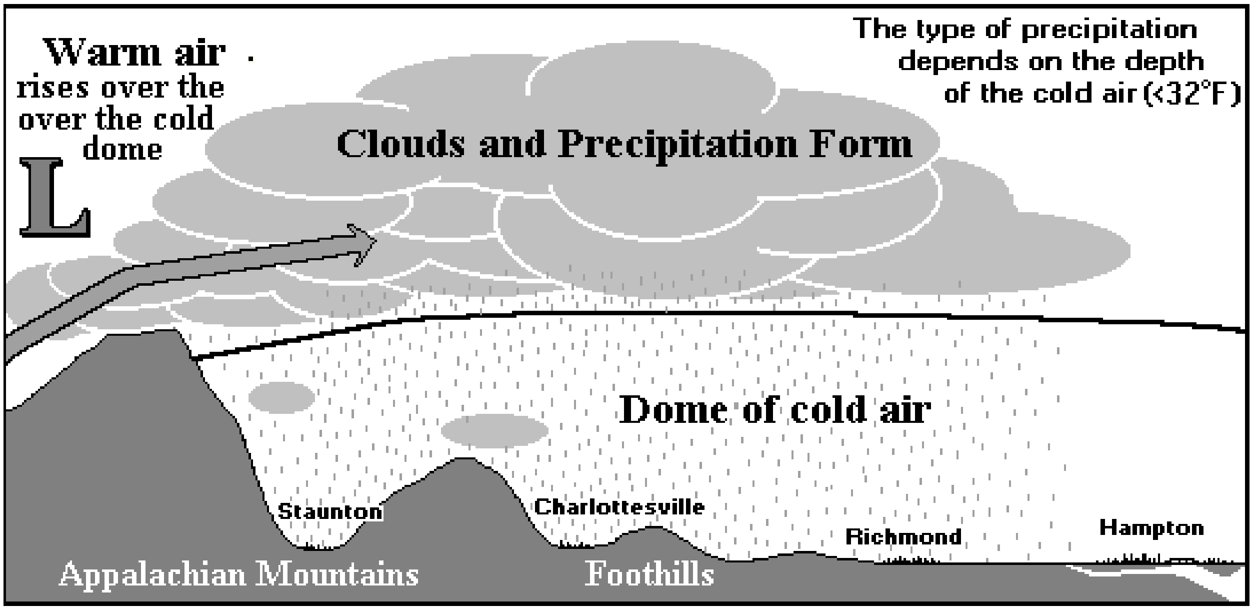


Figure 19: Ice Storm-Formation *(Source: Watson and Sammler 2004).*

Eventually, the cold air mass is so shallow that the rain does not freeze. If the temperature of the earth's surface is below freezing, then rain will freeze as it hits the ground, producing *freezing rain*, a very dangerous on roadways or walkways. As the ice accumulates on trees and wires, the weight eventually causes them to break, knocking out power and phone service. Sometimes, so much ice can accumulate that structural damage and collapse can occur to buildings and communication towers. This is precisely what occurred during the "Christmas Ice Storm" of December 1998, which hit southeast Virginia, including the Middle Peninsula. Icy conditions caused injuries from slips, falls, and numerous vehicle accidents. Ice accumulations of up to an inch brought down trees and power lines. Outages were so widespread (400,000 customers on Christmas Eve) that some people were without power for up to ten days (Watson and Sammler 2004). Other types of weather systems generally do not cause major problems for Virginia. Storms such as the "*Alberta Clipper*," a fast moving storm from the Alberta, Canada region, or a cold front sweeping through from the west generally do not bring more than one to four inches of snow in a narrow 50 to 60 mile-wide band. Sometimes, the high pressure and cold arctic air that follow in the wake of a clipper become the initial set up for a Nor'easter. In very rare cases, elements combine to produce very localized heavy snow without any fronts or storm centers nearby. These events are nearly impossible to forecast with any accuracy (Watson and Sammler 2004).

However in November 2009, Tropic Storm Ida made landfall in Alabama, but weakened, losing its tropical storm characteristics, as it crossed to North Carolina. The storm redeveloped off the coast of Carolina in the Atlantic Ocean. The resulting coastal low combined with an unusually strong Canadian high over New England resulted in a strong pressure gradient over Coastal Virginia and the Carolinas. This caused storming northeasterly winds, high waves and record high water levels. Stations of the coastline of the Virginia recorded wind speeds, gusts and barometric pressures of this Nor'easter (Table).

Table: Maximum observed wind speeds, gusts and barometric pressure by stations located near Middle Peninsula Localities during the November 2009 Nor-easter								
Station Name	**Maximum Wind Speed**			**Maximum Wind Gust**			**Minimum Barometric Pressure**	
	Date & Time (GMT)	**m/s**	**Kt**	**Date & Time (GMT)**	**m/s**	**Kt**	**Date & Time (GMT)**	**mb**
Kiptopeke, VA	11/13 00:00	14.7	29	11/12 21:12	22.3	43	n/a	n/a
Lewisetta, VA	11/12 00:00	12.3	24	11/12 21:30	19.5	38	11/12 8:24	1006.7
Yorktown USCG Training Center, VA	11/12 23:06	21.4	42	11/12 23:12	25.9	50	11/12 23:06	1001.5
Chesapeake Bay Bridge Tunnel, VA	11/12 22:42	26.6	52	11/13 4:24	33.4	65	11/12 4:24	997.0

4.4.2. Coastal Flooding

According to the Virginia Hazards Mitigation Plan coastal flooding occurs when strong onshore winds push water from an ocean, bay or inlet onto the land. In addition, coastal areas experience flooding from overland flow, ponding and inadequate storm water drainage. Coastal flooding may arise from tropical cyclones (hurricanes and tropical storms) or Nor'easters (extratropical storms).

Flooding is the most frequent and costly natural hazard in the United States - besides fire. Nearly 90% of Presidential Disaster Declarations result from natural events where flooding is a major component. Excess water from snowmelt, rainfall, or storm surge accumulates and overflows onto adjacent floodplains and other low-lying land adjacent to rivers, lakes, ponds and the Chesapeake Bay.

Coastal flooding is typically a result of storm surge, wind-driven waves, and heavy rainfall. These conditions are produced by hurricanes during the summer and fall, and nor'easters and other large coastal storms during the winter and spring. Storm surges may overrun barrier islands and push sea water up coastal rivers and inlets, blocking the downstream flow of inland runoff.

Thousands of acres of crops and forest lands may be inundated by both saltwater and freshwater. Escape routes, particularly from barrier islands, may be cut off quickly, stranding residents in flooded areas and hampering rescue efforts. Coastal flooding is very dangerous and causes the most severe damage where large waves are driven inland by the wind. These wind driven waves destroy houses, wash away protective dunes, and erode the soil so that the ground level can be lowered by several feet. Because of the coastal nature of the Middle Peninsula, the region is very susceptible to this type of flooding and resulting damage.

4.4.3. Lightning

Virginia averages 35 to 45 thunderstorm days per year statewide (Watson 2001). Thunderstorms are generally beneficial because they provide needed rain for crops, plants, and reservoirs. Thunderstorms can occur any day of the year and at any time of the day, but are most common in the late afternoon and evening during the summer months. About five percent of thunderstorms become severe and can produce tornadoes, large hail, damaging downburst winds, and heavy rains causing flash floods. Thunderstorm can develop in less than 30 minutes, allowing little time for warning. All thunderstorms produce lightning, which can be deadly. The NWS does not issue warnings for ordinary thunderstorms nor for lightning. The NWS does highlight the potential for thunderstorms in the daily forecasts and statements. The VDEM suggests that the public be alert to the signs of changing weather, such as darkening skies, a sudden wind shift, and drop in temperature, and having a warning device such as NOAA Weather Radio.

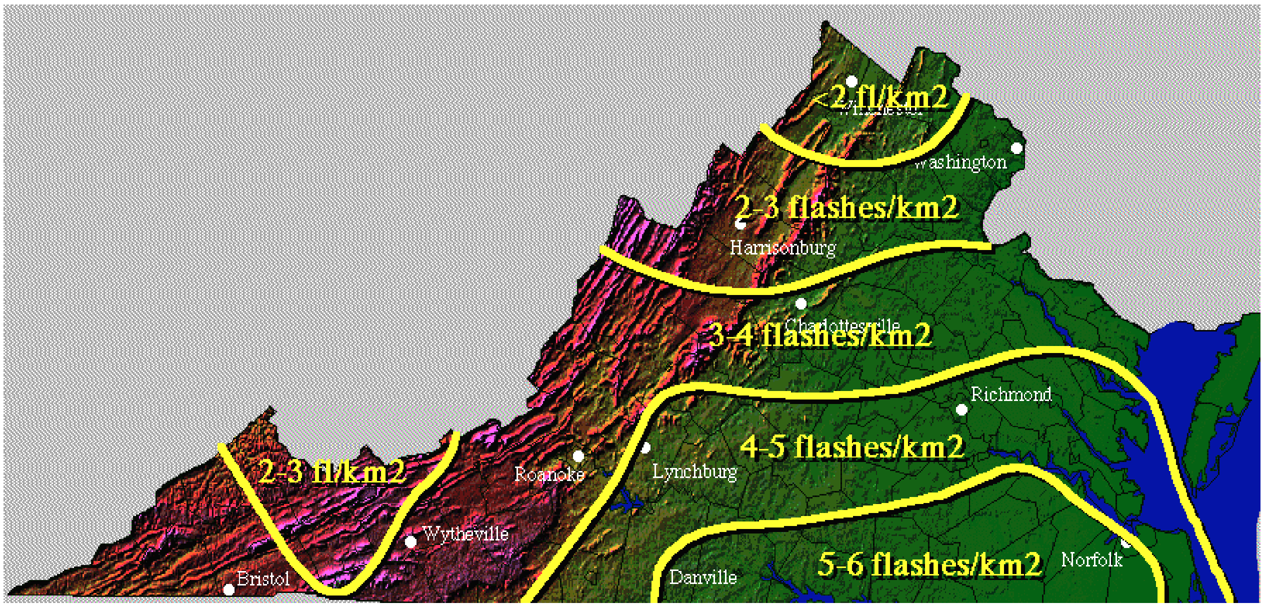


Figure 20: Lightning Flash Density Map *computed for 1989 (Electric Power Institute), courtesy of the University of Virginia, Climate Division: www.climate.virginia.edu/climate/lightning.density.html*

Lightning can strike up to 10 to 15 miles from the rain portion of the storm. The lightning bolt originates from the upper part of the thunderstorm cloud known as the anvil. A thunderstorm can grow up to 8 miles into the atmosphere where the strong winds aloft spread the top of the thunderstorm cloud out into an anvil. The anvil can spread many miles from the rain portion of the storm but it is still a part of that storm. Lightning, from the anvil, may strike several miles in advance of the rain. Lightning bolts may also come from the side or back of the storm, striking after the rain and storm have seemed to pass, or hitting areas that were totally missed by the rain.

Between 1959 and 2014, lightning killed 66 people in Virginia and from 1959 to 1994 has injured at least 238 people. Many additional injuries from lightning go unreported or are not captured by NWS data collection techniques. Nationally, from 1959 through 2014, there have been 4049 deaths due to lightning. Most deaths were males between the ages of 20 and 40 years old who were caught outdoors on fishing, camping, boating or farming /ranching. A national network of 114 lightning ground stroke detectors was put in place by the Electric Power Research Institute (EPRI), a private organization, that serves the needs of power companies and other subscribers interested in lightning across the country (Virginia Climate Advisory, 1992). These detectors sense the characteristic electromagnetic impulses of cloud-to-ground lightning strikes that occur up to several hundred kilometers away. Then, by using triangulation techniques, the network is able to describe the location of every ground strike that it detects in the continental U.S. (Figure 20). It's important to realize that the contours on the map are very general and because accurate, long term records of lightning strikes do not exist, the illustration may not be representative of long-term patterns. Historic data shows that the Middle Peninsula is at a low risk of suffering damages from lightning and thunderstorms, yet it is important to note that thunderstorms and lightning can be very dangerous and can accompany hurricanes and other severe weather events.

Although lightning can be dangerous and/or life threatening, it is hard to generate specific mitigation strategies for this potential natural hazard other than a general public awareness/education campaign associated with thunderstorm/lightning activity.

4.4.4. Hurricanes

Hurricanes are cyclonic storms that originate in tropical ocean waters. Most hurricanes develop in an area 300 miles on either side of the equator. Hurricanes are heat engines, fueled by the release of latent heat from the condensation of warm water. Their formation requires a low-pressure disturbance, sufficiently warm sea surface temperature, a rotational force resulting from the spinning of the earth and the absence of wind shear in the lowest 50,000 feet of the earth's atmosphere.

Hurricanes that impact Virginia form in the so-called Atlantic Basin - from the west coast of Africa towards the Caribbean Sea and Gulf of Mexico. Hurricanes in this basin generally form between June 1 and November 30 – with a peak around mid-September. In an average season, there are about 10 named tropical storms in the Atlantic Basin with 6 of these likely to develop into hurricanes. The busiest hurricane season in the 20th century was in 1933, which saw 21 hurricanes/tropical storms. Two of these storms hit the Tidewater Region and caused significant devastation in the Middle Peninsula - known as the "Chesapeake-Potomac Hurricanes of 1933". By contrast, the 1914 season saw no hurricanes and only one tropical storm.

As a hurricane develops, barometric pressure at its center falls and winds increase. A weather system with winds at or exceeding 39 mph is designated as a tropical storm, which is given a name and closely monitored by the NOAA National Hurricane Center in Miami, Florida. When winds are at or exceed 74 mph, the tropical storm is deemed to be a hurricane. Hurricane intensity is measured using the Saffir-Simpson Scale, ranging from a Category 1 (minimal) to a Category 5 (catastrophic) hurricane.
The scale categorizes the intensity of hurricanes using a linear method based upon maximum sustained winds, minimum barometric pressure and storm surge potential, which are combined to estimate the potential flooding and damage to property given a hurricane's estimated intensity. See the table below for greater details on the characteristics of Category 1 thru Category 5 hurricanes.

Hurricanes have the greatest potential to inflict damage as they cross the coastline from the ocean, which is called landfall. Because hurricanes derive their strength from warm ocean waters, they are generally subject to deterioration once they make landfall. The forward momentum of a hurricane can vary from just a few miles per hour to 40 mph. This forward motion, combined with a counterclockwise surface air flow, makes the right front quadrant of the hurricane the location of the most potentially damaging winds.

Hurricanes have the potential to spawn dangerous tornadoes. The excessive rainfall and strong winds can also cause flash floods, flooding and abnormal rises in sea levels known as storm surges. Although a hurricane may cause a tremendous amount of wind and water damage, the accompanying storm surge is much more dangerous to life and property in coastal regions. The storm surge is a great dome of water typically 50 miles wide that comes sweeping across the coastline near the area where the eye of the hurricane makes landfall. This storm surge, aided by the hammering effect of breaking waves, acts like a giant bulldozer as it sweeps everything in its path. The stronger the hurricane, the higher and more dangerous the storm surge will be. Nine out of ten hurricane fatalities are caused by the storm surge.

Hurricane Wind Extent (Impact)

The Saffir-Simpson Hurricane Wind Scale is a 1 to 5 categorization based on the hurricane's intensity at the indicated time. The scale – originally developed by wind engineer Herb Saffir and meteorologist Bob Simpson – has been an excellent tool for alerting the public about the possible impacts of various intensity hurricanes. The scale provides examples of the type of damage and impacts in the United States associated with winds of the indicated intensity. In general, damage rises by about a factor of four for every category increase.

Category One Hurricane
Very dangerous winds will produce some damage
(Sustained winds 74-95 mph, 64-82 kt, or 119-153 km/hr)
People, livestock, and pets struck by flying or falling debris could be injured or killed. Older (mainly pre-1994 construction) mobile homes could be destroyed, especially if they are not anchored properly as they tend to shift or roll off their foundations. Newer mobile homes that are anchored properly can sustain damage involving the removal of shingle or metal roof coverings, and loss of vinyl siding, as well as damage to carports, sunrooms, or lanais. Some poorly constructed frame homes can experience major damage, involving loss of the roof covering and damage to gable ends as well as the removal of porch coverings and awnings. Unprotected windows may break if struck by flying debris. Masonry chimneys can be toppled. Well-constructed frame homes could have damage to roof shingles, vinyl siding, soffit panels, and gutters. Failure of aluminum, screened-in, swimming pool enclosures can occur. Some apartment building and shopping center roof coverings could be partially removed. Industrial buildings can lose roofing and siding especially from windward corners, rakes, and eaves. Failures to overhead doors and unprotected windows will be common. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. There will be occasional damage to commercial signage, fences, and canopies. Large branches of trees will snap and shallow rooted trees can be toppled. Extensive damage to power lines and poles will likely result in power outages that could last a few to several days. Hurricane Dolly (2008) is an example of a hurricane that brought Category 1 winds and impacts to South Padre Island, Texas.

Category Two Hurricane
Extremely dangerous winds will cause extensive damage
(Sustained winds 96-110 mph, 83-95 kt, or 154-177 km/hr)
There is a substantial risk of injury or death to people, livestock, and pets due to flying and falling debris. Older (mainly pre-1994 construction) mobile homes have a very high chance of being destroyed and the flying debris generated can shred nearby mobile homes. Newer mobile homes can also be destroyed. Poorly constructed frame homes have a high chance of having their roof structures removed especially if they are not anchored properly. Unprotected windows will have a high probability of being broken by flying debris. Well-constructed frame homes could sustain major roof and siding damage. Failure of aluminum, screened-in, swimming pool enclosures will be common. There will be a substantial percentage of roof and siding damage to apartment buildings and industrial buildings. Unreinforced masonry walls can collapse. Windows in high-rise buildings can be broken by flying debris. Falling and broken glass will pose a significant danger even after the storm. Commercial signage, fences, and canopies will be damaged and often destroyed. Many shallowly rooted trees will be snapped or uprooted and block numerous roads. Near-total power loss is expected with outages that could last from several days to weeks. Potable water could become scarce as filtration systems begin to fail. Hurricane Frances (2004) is an example of a hurricane that brought Category 2 winds and impacts to coastal portions of Port St. Lucie, Florida with Category 1 conditions experienced elsewhere in the city.

Category Three Hurricane
Devastating damage will occur
(Sustained winds 111-130 mph, 96-113 kt, or 178-209 km/hr)

There is a high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. Most newer mobile homes will sustain severe damage with potential for complete roof failure and wall collapse. Poorly constructed frame homes can be destroyed by the removal of the roof and exterior walls. Unprotected windows will be broken by flying debris. Well-built frame homes can experience major damage involving the removal of roof decking and gable ends. There will be a high percentage of roof covering and siding damage to apartment buildings and industrial buildings. Isolated structural damage to wood or steel framing can occur. Complete failure of older metal buildings is possible, and older unreinforced masonry buildings can collapse. Numerous windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Most commercial signage, fences, and canopies will be destroyed. Many trees will be snapped or uprooted, blocking numerous roads. Electricity and water will be unavailable for several days to a few weeks after the storm passes. Hurricane Sandy (2012) is an example of a hurricane that brought Category 3 winds and impacts to coastal portions of Cuba, but it downgraded to a Category 2 storm off the coast of the Northeast.

Category Four Hurricane
Catastrophic damage will occur
(Sustained winds 131-155 mph, 114-135 kt, or 210-249 km/hr)
There is a very high risk of injury or death to people, livestock, and pets due to flying and falling debris. Nearly all older (pre-1994) mobile homes will be destroyed. A high percentage of newer mobile homes also will be destroyed. Poorly constructed homes can sustain complete collapse of all walls as well as the loss of the roof structure. Well-built homes also can sustain severe damage with loss of most of the roof structure and/or some exterior walls. Extensive damage to roof coverings, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will break most unprotected windows and penetrate some protected windows. There will be a high percentage of structural damage to the top floors of apartment buildings. Steel frames in older industrial buildings can collapse. There will be a high percentage of collapse to older unreinforced masonry buildings. Most windows will be blown out of high-rise buildings resulting in falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Most trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months. Hurricane Charley (2004) is an example of a hurricane that brought Category 4 winds and impacts to coastal portions of Punta Gorda, Florida with Category 3 conditions experienced elsewhere in the city.

Category Five Hurricane
Catastrophic damage will occur
(Sustained winds greater than 155 mph, greater than 135 kt, or greater than 249 km/hr)
People, livestock, and pets are at very high risk of injury or death from flying or falling debris, even if indoors in mobile homes or framed homes. Almost complete destruction of all mobile homes will occur, regardless of age or construction. A high percentage of frame homes will be destroyed, with total roof failure and wall collapse. Extensive damage to roof covers, windows, and doors will occur. Large amounts of windborne debris will be lofted into the air. Windborne debris damage will occur to nearly all unprotected windows and many protected windows. Significant damage to wood roof commercial buildings will occur due to loss of roof sheathing. Complete collapse of many older metal buildings can occur. Most unreinforced masonry walls will fail which can lead to the collapse of the buildings. A high percentage of industrial buildings and low-rise apartment buildings will be destroyed. Nearly all windows will be blown out of high-rise buildings resulting in

falling glass, which will pose a threat for days to weeks after the storm. Nearly all commercial signage, fences, and canopies will be destroyed. Nearly all trees will be snapped or uprooted and power poles downed. Fallen trees and power poles will isolate residential areas. Power outages will last for weeks to possibly months. Long-term water shortages will increase human suffering. Most of the area will be uninhabitable for weeks or months. Hurricane Andrew (1992) is an example of a hurricane that brought Category 5 winds and impacts to coastal portions of Cutler Ridge, Florida with Category 4 conditions experienced elsewhere in south Miami-Dade County

Hurricane Isabel in 2003 was one of Virginia's costliest disasters, causing widespread devastation and disrupting the lives of thousands of citizens – including those living in the Middle Peninsula. This deadly storm was a Category 2 hurricane when it made landfall between Cape Lookout and Cape Hatteras on North Carolina's Outer Banks on Thursday, September 18, 2003. By the time it reached Virginia, it was downgraded to a Category 1 hurricane. Even though the storm followed a path west of the City of Richmond, Isabel's destructive effects were felt throughout Tidewater Virginia and the entire Mid-Atlantic Region.

Hampton Roads remained in the right front quadrant through most of the storm's landfall, which helped to push the storm surge into many inland areas along the rivers. Property damage resulting from the 4 to 12-foot storm surge was extensive in many parts of the region. Homes, bulkheads and piers were damaged and the winds resulted in significant damage to properties and power lines. Rainfall totaled between 2 and 11 inches along the storm's track. Trees, especially those with shallow root systems, were blown over. Damages due to wind, rain, and storm surge resulted in flooding, electrical outages, piles of debris, transportation interruptions and damaged homes/businesses. Many citizens were without power for several days - with others in remote locations of the Middle Peninsula without power for up to three weeks.

Statewide losses to residential property were estimated to exceed $590 million and businesses reported over $84 million in losses. Thirty-two deaths were directly or indirectly attributed to this storm in Virginia. One of these deaths was in Gloucester County when an individual died of a heart attack after their vehicle was swept up in high water. Hurricane Isabel is considered one of the most significant tropical cyclones to affect portions of northeastern North Carolina and east-central Virginia since Hurricane Hazel in 1954 and the Chesapeake-Potomac Hurricane of 1933 (Beven and Cobb, 2004).

Although Virginia was spared a direct hit, the hurricane season of 2004 may be the costliest on record in the United States. Fifteen tropical or subtropical storms formed in the North Atlantic. Nine of these storms become hurricanes with six becoming major hurricanes of Category 3 or higher on the Safflir-Simpson Hurricane Scale. Six of the hurricanes, Alex, Charley, Frances, Gaston, Ivan and Jeanne, and three tropical storms struck the United States in 2004. The strongest hurricane was Ivan, which reached Category 5 status. Ivan was directly blamed from 26 deaths and damage estimates were $13 billion in the United States.

With 4 hurricanes and tropical storms hitting the United States in a 5-week period, 2004 has been labeled as the year of the hurricane according to leading experts who participated in a Center for Health and the Global Environment briefing at Harvard Medical School (Compass Publications, Inc. 2004). They report that the intense period of destructive weather may be a harbinger of what is to come. Hurricanes have been on the increase over the past decade as part of a natural multi-decadal cycle (Ananthaswamy 2003). These storms are more likely to form when the Atlantic is warm, as it was from the 1930s to the 1960s.

Although the decades since the 1960s have seen fewer hurricanes, numbers have risen since 1995 and may not have reached the predicted peak yet. While experts cannot say that climate change will result in more hurricanes in the future, there is growing evidence and concern that tropical storms that do occur will be more intense than those in the past as the effects of global warming become even more pronounced in future years.

By virtue of its position along the Atlantic Ocean and near the Gulf Stream, southeastern Virginia is frequently impacted by hurricanes. Continuous weather records for the Hampton Roads Area of Virginia began on January 1, 1871 when the National Weather Service was established in downtown Norfolk. However, the recorded history of significant tropical storms that affected the area goes back much further.

Prior to 1871, very early storms have been described in ship logs, newspaper accounts, history books, and countless other writings. The residents of coastal Virginia during Colonial times were very much aware of the weather. They were a people that lived near the water and largely derived their livelihood from the sea. To them, a tropical storm was indeed a noteworthy event. The excellent records left by some of Virginia's early settlers and from official records of the National Weather Service are summarized in the "*Chronology of Middle Peninsula Hazard Events.*"

Since 1953, Atlantic tropical storms have been named from lists originated by the National Hurricane Center. The lists featured only women's names until 1979, after which male and female names were included in the lists for both the Atlantic and Gulf of Mexico storms. Whenever a hurricane has had a major impact, any country affected by the storm can request that the name of the hurricane be "retired" by agreement of the World Meteorological Organization (WMO). Retiring a name actually means that it cannot be reused for at least 10 years, to facilitate historic references, legal actions, insurance claim activities, etc. and to avoid public confusion with another storm of the same name. Retired names for storms that hit the Tidewater Region include Agnes (1972), Cleo (1964), David (1979), Donna (1960), Floyd (1999), Fran (1996), Gloria (1985), Gracie (1959), Hazel (1954), and Isabel (2003) (NOAA Atlantic Oceanographic and Meteorological Laboratory, Hurricane Research Division).

Middle Peninsula Storm Surge Hazard Maps

In order to estimate the geographic extent of potential damage from these hurricanes, a review of the 2008 Middle Peninsula Storm Surge Hazard Maps show the worst case scenario of hurricane storm surge inundation at mean tide. Figures 18- 21 are maps developed by the U.S. Corp of Engineers in conjunction with the VDEM as part of their 2008 Virginia Hurricane Evacuation Study.

Due to the nature of the study, only Mathews, Gloucester and Middlesex Counties in the Middle Peninsula were included since they are considered coastal counties that suffer greatly from tidal surge impacts and therefore have impacts for evacuating residents from low-lying areas. Although the limits of the study only included the lower half of our region, it should be noted that all of the Middle Peninsula localities experienced storm surges during the latest severe storm - Hurricane Isabel in September 2003.

The data reflects only still salt water flooding. Freshwater flooding may also occur with hurricane events from heavy rainfall runoff, and waves may accompany the surge and cause further inundation. The maps represent the surge from Category 1 through 4 hurricanes. State and federal officials do not include storm surges from a Category 5 hurricane since they do not believe that the ocean water temperature off of the Virginia Coast is warm enough for such an intense storm.

Figures 21 through 24 summarize surge height estimates using the SLOSH (Sea, Lake, and Overland Surges from Hurricane) Model. The model was developed by Chester Jelesnianski of the National Oceanic and Atmospheric Administration, National Weather Service. The storm surge computations and analysis were conducted by the Storm Surge Group of the National Hurricane Center.

The SLOSH model was used to develop data for various combinations of hurricane strength, wind speed, and direction of movement. Hurricane strength was modeled by use of central pressure (defined as the difference between the ambient sea level pressure and the minimum value in the storm's center), the storm eye size, and the radius of maximum winds (using four of the five categories of each hurricane intensity as depicted in the Saffir-Simpson Hurricane Scale). The modeling for each hurricane category was done using the mid-range wind speed for that category. Six storm track headings (WNW, NW, NNW, N, NNE, NE) were selected as being representative of storm behavior in the Virginia region, based on observations by forecasters at the National Hurricane Center. Additional inputs into the model included depths of water offshore, the heights of the terrain and onshore barriers.

Figure 21: Storm Surge Inundation Map of Middlesex, Gloucester, and Mathews Counties (Source: Virginia Department of Emergency Management, 2008).

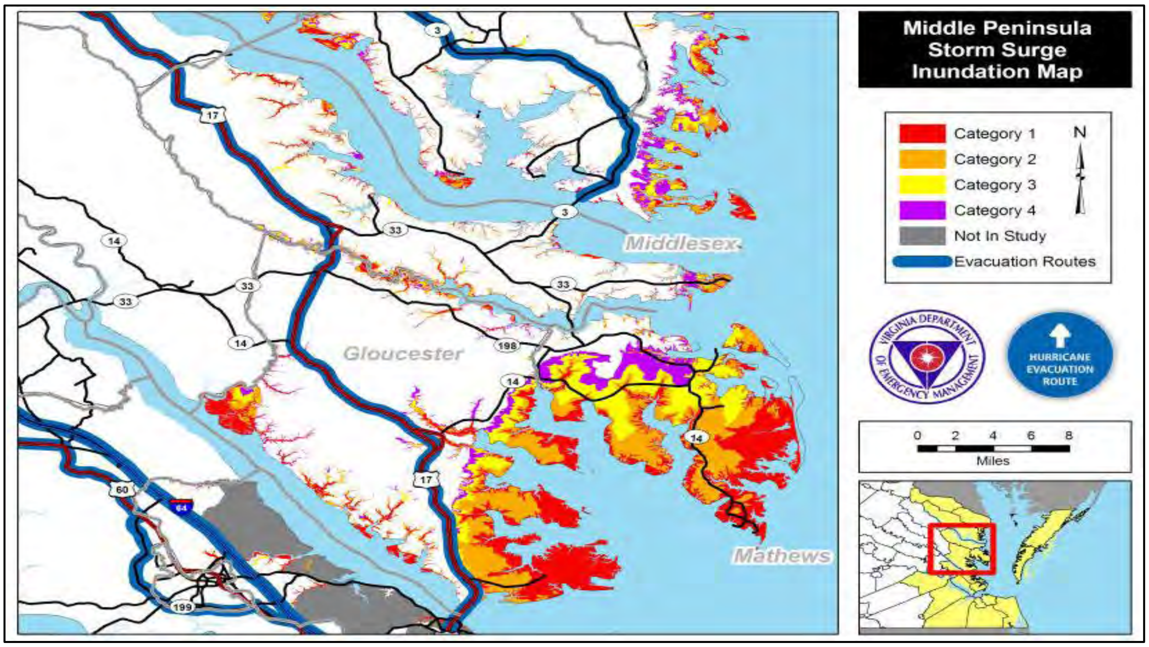


Figure 22: Storm Surge Inundation Map of Middlesex County (Source: Virginia Department of Emergency Management, 2008).

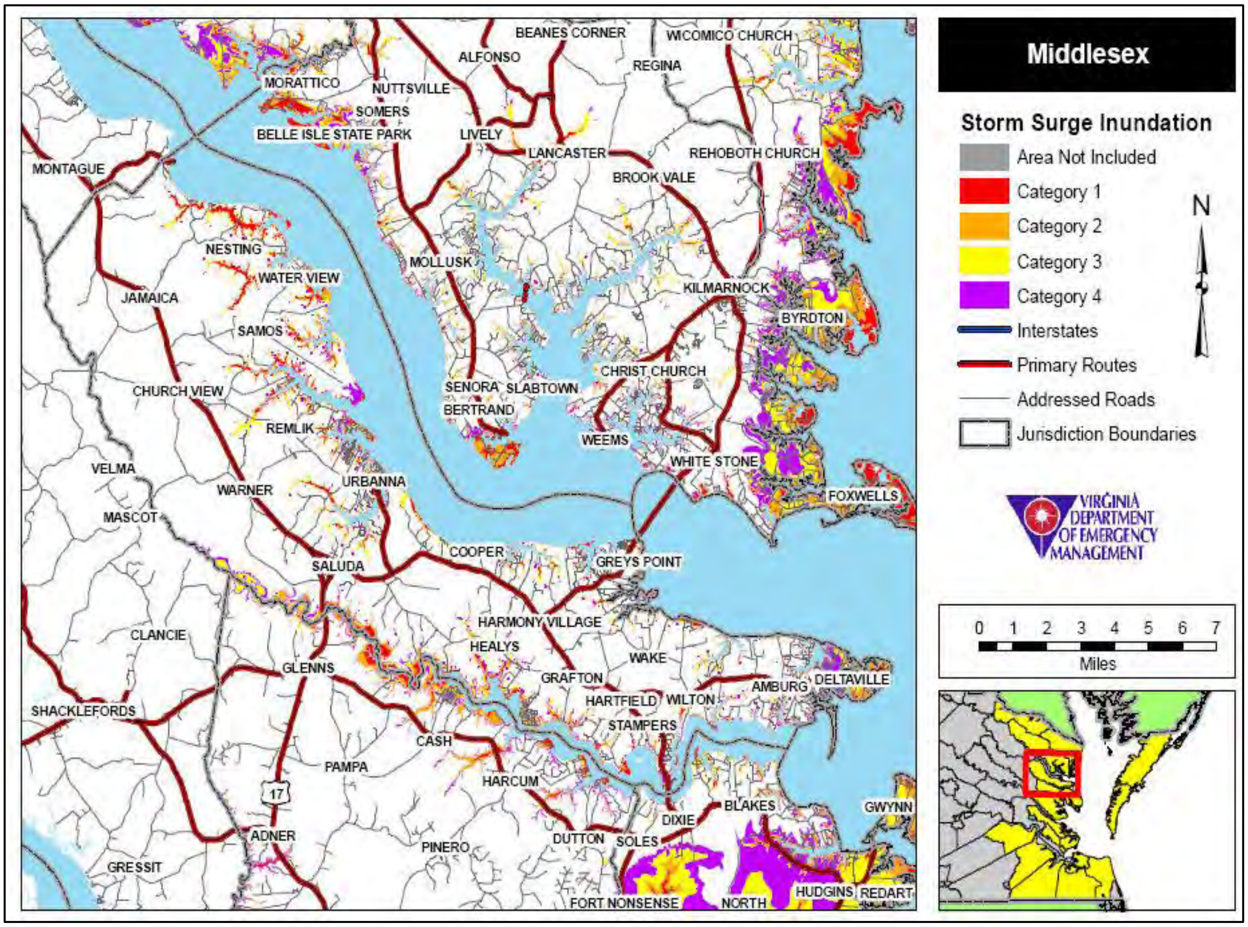


Figure 23: Storm Surge Inundation Map of Mathews County (Source: Virginia Department of Emergency Management, 2008).

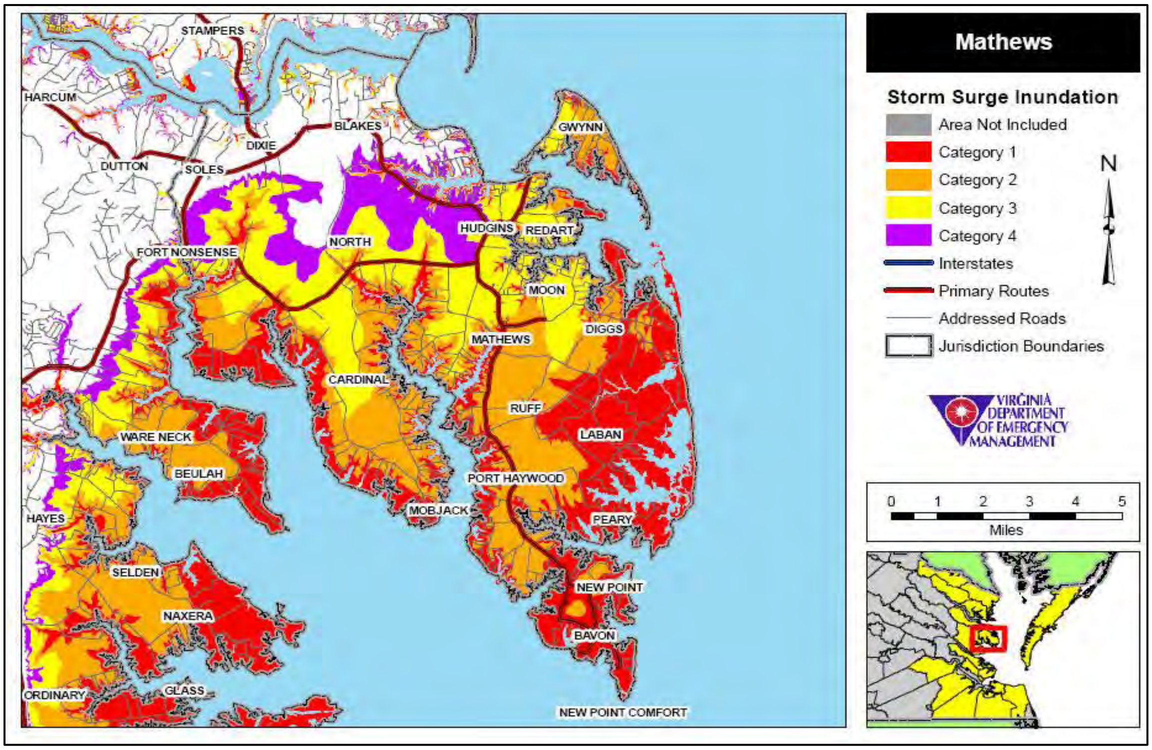
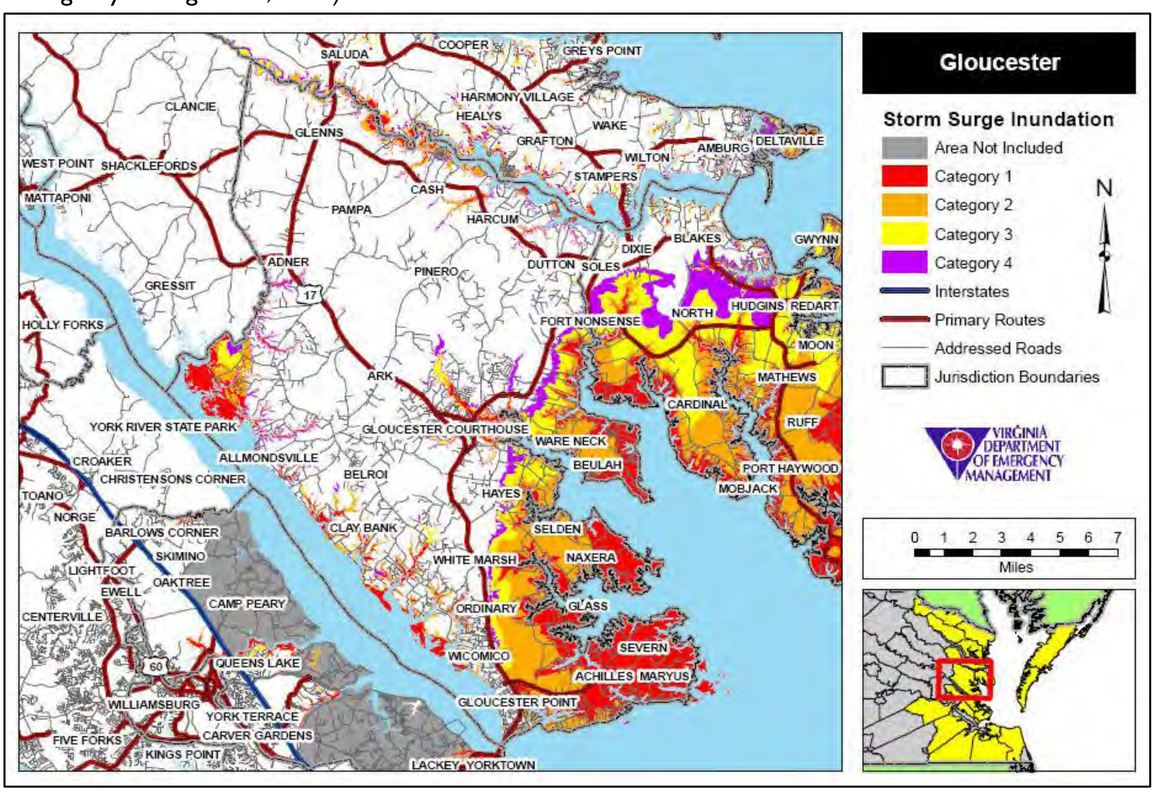


Figure 24: Storm Surge Inundation Map of Mathews County (Source: Virginia Department of Emergency Management, 2008).



Historical Occurrences
In evaluating localized threats of hurricanes and tropical storms to the Middle Peninsula Region, NOAA hurricane tracking data from 1851 to 2014 was analyzed to identify storms that may have posed a threat to the region.

Based on these data, 43 storms - including hurricanes, tropical storms and tropical depressions - passed within 25 nautical miles of the Middle Peninsula Region. Of these storms,

- 2 were hurricanes,
- 22 were tropical storms,
- 8 were tropical depressions, and
- 11 were extra-tropical storms.

Over the same period of time, 60 storms passed within 50 nautical miles of the region and

- 4 of these storms were hurricanes,
- 31 were tropical storms,
- 11 were tropical and subtropical depressions, and
- 14 were extra-tropical storms.

Table 15: Historic Storm Tracks within 50 and 25 nautical mile radii of the Middle Peninsula between 1851 and 2014.

Type of Storm	Quantity passing within 50 nm	Quantity passing within 25 nm
Hurricane – Category 5 (winds >155 mph)	0	0
Hurricane – Category 4 (winds 131-155 mph)	0	0
Hurricane – Category 3 (winds 111-130 mph)	0	0
Hurricane – Category 2 (winds 96-110 mph)	1	1
Hurricane – Category 1 (winds 74-95 mph)	3	1
Tropical Storm (winds 39-73 mph)	31	22
Tropical Depression (winds <38 mph)	10	8
Subtropical Storm (winds 39-73 mph)	0	0
Subtropical Depression (winds <38 mph)	1	0
Extra-tropical Storm (winds <39 mph)	14	11
Total:	**60**	**43**

General Chronology of Middle Peninsula Coastal Storm Hazard Events
Because of its proximity to the Atlantic Coast and Chesapeake Bay, the Middle Peninsula has been impacted by coastal storms throughout recorded history, and therefore it is not surprising that hurricanes, coastal flooding, nor'easters, and coastal/shoreline erosion were among the top ranked hazards affecting the Middle Peninsula Region as ranked by the Regional Risk Assessment and Mitigation Planning Committee in 2005 and re-affirmed by the Middle Peninsula Flood Mitigation Plan Team Members in 2009.

Hurricanes come close enough to produce hurricane force winds approximately three times every 20 years. Two or three times a century, winds and tides produce considerable damage and significantly threaten life. Historical records are invaluable to researchers trying to understand long-term patterns in the frequency and intensity of coastal storms and such data on storms and weather go back a long time in

Virginia, thanks to record keeping by early weather observers such as George Washington, James Madison and Thomas Jefferson as well as journals/articles written by early settlers. The following is a brief synopsis of the major coastal storm events that have impacted the Middle Peninsula Region.

From 1564 to 1799

Hurricanes played an important role during the European exploration and colonization of the Americas. Great storms that besieged Virginia influenced the establishment of new settlements and changed the coastal geography, particularly on the Middle Peninsula. While official weather records did not begin until 1871 in Norfolk, tremendous coastal storms were often recorded through the shipwrecks they induced and in the writings of the early Virginia colonists.

The records of hurricane and tropical storm occurrences during this era are sparse compared to modern-day accounts, since the colonies were not settled until the early 1600's. The original settlers at Jamestown experienced the wrath of such storms firsthand and it is suggested that the lost colony of Roanoke Island may have been doomed by a coastal storm. The first such storm to be recorded occurred in 1564. Others followed in June 1566, June 1586, August 1587, and August 1591. A September 1667 storm, deemed the "Dreadful Hurry Cane of 1667", destroyed thousands of homes in Virginia (Brinkley 1999). Twelve days of rain was said to have followed this storm, causing the Chesapeake Bay to rise 12 feet. This storm and a July 1788 hurricane may have followed a similar track as the 1933 hurricane, which caused massive devastation to the Middle Peninsula.

The October Hurricane of 1749 was a great disaster for Virginians. It formed Willoughby Spit in Norfolk and put the city streets of Hampton 4 feet below water. The Bay was said to have risen 15 feet above normal, destroying waterfront buildings (Ludlum 1963). At least 50 vessels were driven ashore along the Virginia coast, with a loss of 22 lives. Damage in and around the city of Norfolk was estimated to be at least 30,000 Virginia Pounds (approximately $3 million in today's currency - Brinkley 1999).
The September 8, 1769 hurricane, considered one of the worst storms of the eighteenth century, passed over Williamsburg. Damage was "inconceivable" and crops were destroyed. Many old homes and trees were leveled. Heavy rain ruined tobacco crops and flooded roads. Tobacco in storage warehouses was also damaged. Heavy damage was seen in Chesapeake Bay. High winds tore off the top of a wharf at Yorktown and a schooner rammed a nearby storehouse. Four ships in the York River were driven ashore. Two ships on the James River were also wrecked. A vessel from Norfolk, filled with coal from Williamsburg, was forced up to Jamestown before it went to pieces (Roth and Cobb 2001).

"The Independence Hurricane" of September 1775 ravaged the coast between Currituck, N.C. and Chincoteague on the Eastern Shore. Wharves and storehouses on the waterfront of Norfolk were devastated. Raging waters carried bridges away. At Williamsburg, mill-dams broke and corn stalks were blown flat. Many ships were damaged as they were thrown ashore at Norfolk, Hampton, and York. A full blockade of Hampton Roads thereafter brought shipping to a halt for three months. At least 25 died due to a shipwreck. On September 9, 1775, a Williamsburg correspondent of the Virginia Gazette wrote, "The shocking accounts of damage done by the rains last week are numerous; most of the mill-dams are broke, the corn laid almost level with the ground, and fodder destroyed; many ships and other vessels drove ashore and damaged at Norfolk, Hampton, and York. The death toll in Virginia and North Carolina was 163 lives (Roth and Cobb 2001).

A strong gale played a role in a battle between the Royal Governor of Virginia, Dunmore, and General Lewis of the rebel forces on July 10, 1776. The royal fleet had been injured prior to the storm by General Lewis' forces and was sailing from Gwynn's Island (Mathews County) toward St. George's Island, in the Potomac. The British crew was without water and enduring smallpox when the gale struck. A flour-laden supply ship ran aground. One ship foundered at the Mouth of the Rappahannock, while another was stranded on the Eastern shore (Roth and Cobb 2001).

On October 16, 1781, a storm of "unknown character" struck Virginia. The French Fleet and the Patriot Army, under the command of George Washington, trapped the Earl of Cornwallis at Yorktown. The Earl decided to flee to the north to Gloucester Point under the cover of darkness. A "furious storm" doomed the plan to failure, as seas ran high and every boat was "swamped." He sent forward his flag of truce and surrendered, thus ending the battle (Roth and Cobb 2001).

The "most tremendous gale of wind known in this country" passed over the Lower Chesapeake Bay September 22-24, 1785 and went along a track very similar to the Chesapeake-Potomac Hurricane of 1933 and likely severely impacted the Middle Peninsula. At Norfolk, lower stories of dwellings were flooded. Warehouses were totally carried away by the storm surge, causing large amounts of salt, sugar, corn, and lumber to disappear. A large number of cattle drowned, and people hung onto trees for dear life during the tempest. Vessels floated inland into cornfields and wooded areas (Roth and Cobb 2001).

"George Washington's Hurricane" of July 23-24, 1788, made landfall in Virginia and passed directly over the Lower Chesapeake Bay and Mount Vernon, the home of George Washington. This track is very similar to the track of the Chesapeake-Potomac Hurricane of 1933. At Norfolk, winds increased at 5 p.m. on the 23rd with the wind originating from the northeast. At 12:30 a.m., the wind suddenly shifted to the south and "blew a perfect hurricane, tearing down chimneys, fences, and leveling corn." In addition, large trees were uprooted and houses were moved from their foundations. Port Royal (Caroline County) and Hobb's Hole (Essex County) experienced a violent northeast gale, which drove several vessels ashore. In Fredericksburg, great quantities of corn, tobacco, and fruit were destroyed. Houses and trees fell in great numbers across Northumberland, Lancaster, Richmond and Westmoreland Counties on the Northern Neck. Crops were destroyed and many livestock perished in lower Mathews County. Many plantations saw their houses leveled. Homes were flooded with water six feet deep and several inhabitants drowned. Gloucester County was inundated, and an estimated $400,000 (in 1788 dollars) in damage was incurred (Roth and Cobb 2001).

1800-1899

Great Coastal Hurricane of 1806 (August 23) caught British and French ships off guard, while engaged in the Napoleanic Wars in the U.S. shipping lanes. The British man-of-war *L'Impeteax* drifted under jury masts for 23 days before finally beaching near Cape Henry. Ships of the two warring nations put in for repair and refitting at the port of Norfolk after the storm. This hurricane, due to its slow movement and consequent erosion of the coastline, completed the creation of Willoughby Spit at Hampton Roads. A seawall built to prevent further erosion at Smith Point lighthouse at the mouth of the Potomac River was damaged (Roth and Cobb 2001).

A severe coastal storm dropped heavy rains on the Fredericksburg area in January 1863. It rained for 30 hours, dropping more than twelve inches, making mud so deep that mules and horses died attempting to move equipment. The rivers became too high and swift to cross, disrupting the Union Army offensive operation in the ill-famed "Mud March" (Watson and Sammler 2004).

The Gale of '78 was one of the most severe hurricanes to affect eastern Virginia in the latter half of the 19th century and struck on October 23, 1878. This hurricane moved rapidly northward from the Bahamas on October 22nd and struck the North Carolina coast later that same day moving at a forward speed of 40 to 50 mph. The storm continued northward passing through east central Virginia, Maryland, and eastern Pennsylvania. Cobb and Smith Islands on the Eastern Shore were completely submerged during this storm (Roth and Cobb 2001).

A September 1882 tropical storm, the "protracted and destructive rain storm", swept away four mills near Ware's Wharf along the lower Rappahannock. The brunt of the cyclone only extended fifty miles inland. Heavy rains were also seen at Washington, D.C. (Roth and Cobb 2001).

During an April 1889 Nor'easter, the Tidewater Region had sustained winds from the north of 75 mph measured at Hampton Roads and 105 mph at Cape Henry. Tides at Norfolk reached 8.37 feet above Mean Low Water, which is over 4 feet above flood stage level (Watson and Sammler 2004).

Noteworthy hurricanes or tropical storms also occurred in September 1821 (one of the most violent on record for the 19th century), June 1825, August 1837, September 1846 (which formed Hatteras and Oregon Inlets in North Carolina), August 1850, September 1856, September 1876, August 1879, October 1887, August 1893, September 1894, October 1897 (tides in Norfolk rose 8.1 feet above Mean Lower Low Water), and October 1899 (tide in Norfolk rose 8.9 feet above Mean Lower Low Water).

From 1900 to 1999
A number of coastal storms hit the Tidewater Region in the early part of the 20th century. Hurricanes and tropical storms in October 1903, August 1924, September 1924, August 1926, and September 1928 each brought high winds (in excess of 70 mph measured in Norfolk and in Cape Henry). The 1903 and 1928 storms also raised tides as much as 9 feet and 7 feet, respectively, higher than normal in the region (Roth and Cobb 2001).

The summer of 1933 was the most active storm season for eastern Virginia in the 20th century. Two hurricanes, one on August 23 and one on September 16, struck the North Carolina and Virginia coasts and caused much devastation on the Middle Peninsula. In Chesapeake lore, the "Storm of '33" is recalled by older residents and enshrined in legend as the worst storm in memory (Mountford 2003). The August storm brought winds in excess of 80 mph and a storm surge that forced the tide nearly 10 feet above normal.

The September storm struck the area 24 days later and had sustained winds as high as 88 mph (measured at the Naval Air Station in Norfolk) and the tide reached 8.3 feet above Mean Lower Low Water (Roth and Cobb 2001). Much of the land around the New Point Comfort lighthouse, the third oldest light on the Bay located at the entrance to Mobjack Bay and the mouth of the York River in Mathews County, was washed away and caused the lighthouse to be stranded on a very small island a few 100 yards from the tip of the mainland.

Hurricane Hazel hit eastern Virginia on October 15, 1954. This storm brought with it gusts of 100 mph which is the highest wind speed record at the Norfolk Airport location. A reliable instrument in Hampton recorded 130 mph winds (Roth and Cobb 2001).

A severe nor'easter gave gale force winds (40+ mph) and unusually high tides to the Tidewater Virginia area on April 11, 1956. At Norfolk, the strongest wind gust was 70 mph. The strong northeast winds blew for almost 30 hours and pushed up the tide, which reached 4.6 feet above normal in Hampton Roads. Thousands of homes were flooded by the wind-driven high water and damages were huge. Two ships were driven aground. Waterfront fires were fanned by the high winds. The flooded streets made access by firefighters very difficult, which added to the losses (Watson and Sammler 2004).

The "Ash Wednesday Storm" hit Virginia during "Spring Tide" (sun and moon phase to produce a higher than normal tide) on March 5-9, 1962. The storm moved north off the coast past Virginia Beach and then reversed its course moving again to the south and bringing with it higher tides and higher waves which battered the coast for several days. The storm's center was 500 miles off the Virginia Capes when water reached 9 feet at Norfolk and 7 feet on the coast. Huge waves toppled houses into the ocean and broke through Virginia Beach's concrete boardwalk and sea wall. Houses on the Middle Peninsula also saw extensive tidal flooding and wave damage. The beaches and shorefront had severe erosion (Watson and Sammler 2004).

Hurricane Cleo in September 1964 produced the heaviest coastal rainfall in the area (11.40 inches in 24 hours) since records began in 1871 (Roth and Cobb 2001).

Hurricane Agnes was downgraded to a tropical depression by the time it moved into Virginia in June 1972, but the rainfall produced by Agnes made this storm more than twice as destructive as any previous hurricane in the history of the United States (Roth and Cobb 2001).

In July 1996, Hurricane Bertha passed over portions of Suffolk and Newport News. Bertha spawned 4 tornadoes across east-central Virginia. The strongest, an F1 tornado, moved over Northumberland County injuring 9 persons and causing damages of several million dollars. Other tornadoes moved over Smithfield, Gloucester and Hampton (Roth and Cobb 2001).

In September 1999, Hurricane Floyd produced 10 to 20 inches of rain on saturated ground and resulted in a recorded 500-year flood for Franklin, VA. While North Carolina and southeastern Virginia were hit with the brunt of this storm, significant damage from downed trees and localized flooding occurred and all of the counties of the Middle Peninsula were included in the Federal Disaster Declaration (FEMA FEMA-1293-DR, Virginia).

From 2000 to 2009

Hurricane Isabel hit the coasts of North Carolina and Virginia on September 18, 2003. It was a Category 1 hurricane when it made landfall. The highest sustained wind was 72 mph at Chesapeake Light. Storm surge varied significantly across the region. At Sewell's Point in Norfolk, the maximum water level was 7.9 feet above MLW. This represented a 5-foot storm surge - the biggest in the region since Hurricane Hazel in 1954. Thirty six deaths were attributed to Hurricane Isabel in Virginia, including one in Gloucester County. Total damages for the Hampton Roads area amounted to $506 million.

In 2004, Tropical Storm Gaston caused serious damage to a handful of VDOT Secondary Roads in the Central Garage/Manquin sections of King William County.

In 2006, Tropical Storm Ernesto caused residential and roadway flooding damage as well as beach erosion damage in Mathews County.

There were an additional 5 named tropical events during this period to hit the Middle Peninsula region resulting in minor severe weather damage.

In 2009 Middle Peninsula coastal localities experienced a significant Nor-Easter with high winds and coastal flooding.

From 2010-2014

Hurricane Irene was hit the coast of North Carolina and had impacts on the Virginia coastal on August 26-27, 2011. Heavy rain, including some totals more than 10 inches, fell on eastern sections of Virginia. Irene lashed the eastern third of Virginia with tropical storm and isolated hurricane force gusts.

In early September 2011, the remand of Tropical storm Lee produced flash flooding in some sections of eastern Virginia, with the Washington, DC, suburbs particularly hard hit.

Hurricane Sandy ate season hurricane that passed off the Mid Atlantic coast, before turning west, and striking the New Jersey & New York coast on October 29, 2012. Sandy was a very large storm that was transitioning from a tropical to a non-tropical storm as it moved north paralleling the U.S. East coast during the October 27-29 time frame. Sandy's impact was relatively small in Virginia, with very heavy rainfall and some flooding the biggest impacts. The most significant impact was felt on the DELMARVA, especially on the east side of the Chesapeake Bay from Salisbury, MD southward to Onancock, VA, where severe coastal flooding and storm surge inundated many areas, as Sandy passed by to the north. Crisfield, MD and Saxis, VA were hardest hit, with millions of dollars in damage to homes and businesses. Damage and flooding were worse than that which occurred in the same area during Hurricane Floyd (1999).

On record for the 2014 season, eight name tropical or subtropical storms formed in the North Atlantic. Six of these became hurricanes and two of these reached major hurricanes of Category 3 or higher on the Saffir-Simpson Hurricane Scale. Six of the hurricanes, Arthur, Bertha, Cristobal, Edouard, Fay, Gonzalo and Hanna, and one tropical storm struck the United States. According to the NWS, activity in the basin in 2-14 was only about 63% of the 1981-2010 average.

Soil Erosion

Hurricanes and nor'easters produce severe winds and storm surges that create significant soil erosion along rivers and streams in the Middle Peninsula. In addition to the loss of soil along these water bodies, there is damage to man-made shoreline hardening structures such as bulkheads and rap-rap as well as to piers, docks, boat houses and boats due to significant storm surges.

These damages are more severe along the broad open bodies of water on major rivers located closer to the Chesapeake Bay. In general terms, the damage is less intense as you move up the watershed from the southeastern area of the region towards the northwestern end of the Middle Peninsula. Therefore, the soil erosion would is most severe in Mathews, Gloucester and Middlesex Counties and to a lesser degree in the 3 remaining Middle Peninsula Counties of King and Queen, King William and Essex Counties.

The location and the angle at which these hurricanes/nor'easters come ashore region can significantly affect the amount of soil erosion during a particular storm. It can generally be said that hurricane generated soil erosion is uneven in occurrence and that the storm surge affords 2 opportunities for erosion – once as water inundates low-lying amount coast lands and again as floodwaters ebb.

For example with Hurricane Isabel in 2003, its enormous wind field tracked in a north-northwest direction to the west of the Chesapeake Bay with the right front quadrant blowing from the south-southeast. This pushed the storm surge up the Bay and piling it into the western shore – causing serious soil erosion to the eastern land masses in Mathews, Gloucester and Middlesex Counties.

Destructive as it was, Hurricane Isabel might have been worse. If it had been stronger at landfill, the storm surge generated in the Chesapeake Bay may have been higher. Had it stalled along its path and lingered through several tide cycles, prolonged surge conditions, exacerbated by high winds, might have cause more severe erosion. If rainfall has been higher, bank erosion due to slope failure might have been more common, particularly given the wetter than normal months that preceded Hurricane Isabel.

Middle Peninsula Resources at Potential Risk of Loss
Floodplain Properties and Structures

While floodplain boundaries are officially mapped by FEMA's National Flood Insurance Program (NFIP), flood waters sometimes go beyond the mapped floodplains and/or change courses due to natural processes (e.g., accretion, erosion, sedimentation, etc.) or human development (e.g., filling in floodplain or floodway areas, increased imperviousness areas within the watershed from new development, or debris blockages from vegetation, cars, travel trailers, mobile homes and propane tanks).

Since the floodplains in the United States are home to over 9 million households and there continues to be a high demand for residential and commercial development along water features, most property damage results from inundation by sediment and debris-filled water. Flooding is one of the most significant hazards faced by the Middle Peninsula. A majority of the flooding that has damaging affects on the region is tidal flooding, which primarily occurs in conjunction with severe coastal storms such as hurricanes or nor'easters.

In addition to tidal flooding, some regions of the Middle Peninsula are subject to flooding events induced by rain associated with a hurricane or a tropical storm, which can produce extreme amounts of rainfall in short periods of time. In August 2004, Tropical Storm Gaston dumped 14 inches of rain in a matter of hours on King William County, washing out numerous roads and bridges. This storm qualified the county for disaster aid through a Presidential Disaster Declaration.

Flooding of vacant land or land that does not have a direct effect on people or the economy is generally not considered a problem. Flood problems arise when floodwaters cover developed areas, locations of economic importance, infrastructure or any other critical facility. Low-lying land areas of Essex, Gloucester, Mathews, and Middlesex Counties and the lower reaches of King and Queen and King William Counties are highly susceptible to flooding, primarily from coastal storm when combined with tidal surges.

These flood-prone regions include marsh areas adjacent to waterways, and the wide, flat outlets where its streams and rivers meet the Chesapeake Bay and its tributaries. Fluctuations in the surrounding water levels produce a mean tidal range of approximately 3 feet. The timing or coincidence of maximum surge-producing forces with the normal high tide is an important factor in consideration of flooding from tidal sources. Strong winds from the east or southeast can push Chesapeake Bay water into the mouth of the York and Rappahannock Rivers and Mobjack Bay – thereby flooding lower portions of the Middle Peninsula. This surge combined with the normal high tide can increase the mean water level by 15 feet or more.

The Flood Insurance Rate Maps (FIRMs) show flooding during a 100-year storm event or, in other words, the storm that has a 1% chance of being equaled or exceeded in any given year. The FIRMs account for both coastal surge driven flooding, as well as flooding generated from rain events. The 1% annual-chance-flood (or the 100-year flood as it is commonly referred to) represents a magnitude and frequency that has a statistical probability of being equaled or exceeded in any given year. Another way of looking at it is that the 100-year flood has a 26% (or a 1 in 4) chance of occurring over the life of a 30-year mortgage on a home (FEMA 2002).

Along with nearly 20,000 communities across the country, all of the localities in the Middle Peninsula voluntarily participate in the National Flood Insurance Program by adopting and enforcing floodplain management ordinances in order to reduce future flood damage. In exchange, the NFIP makes federally backed flood insurance available to homeowners, renters, and business owners in these communities (FEMA 2002).

The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. Flood insurance is designed to provide an alternative to disaster assistance to reduce the escalating costs of repairing damage to buildings and their contents caused by floods. Flood damage is reduced by nearly $1 billion a year by communities implementing sound floodplain management requirements and property owners purchasing flood insurance.

Additionally, buildings constructed in compliance with NFIP building standards suffer approximately 80% less damage annually than those not built in compliance with these standards. It is estimated that for every $3 paid in flood insurance claims, there is $1 spent in disaster assistance payments (FEMA 2002).

Mapping flood hazards creates broad-based awareness of the flood hazards and provides the data needed for local floodplain management programs and to provide flood insurance actuarial rates for new construction (FEMA 2002).

Floodplain maps covering the Middle Peninsula Region have recently been updated. FEMA produced these new digital maps in the following years:

2015
Essex County
Middlesex County

2014
Gloucester County
Mathews County

2013
King & Queen County
King William County

The recently completed digital floodplain maps/data can be integrated into the Geographic Information Systems (GIS) of those Middle Peninsula localities that utilize GIS technology.

When creating the FIRMs, floodplain zones are standardized to the 100-year flood and assigned an area called the Special Flood Hazard Area (SFHA). A SFHA is a high-risk area defined as any land that would be inundated by a flood having a 1-percent chance of occurring in any given year (FEMA 2002). In the Middle Peninsula, the SFHA includes zones designated as VE, A, AE and X.

Table 16. FEMA Flood Zone Designations found in the Middle Peninsula Region.

Zone VE and V	SFHA along coasts subject to inundation by the 100-year flood with additional hazards due to velocity (wave action). Base flood elevations derived from detailed hydraulic analyses are shown within these zones. *Mandatory flood insurance purchase requirements apply.*
Zone A	SFHA subject to inundation by the 100-year flood. Because detailed hydraulic analyses have not been performed, no base flood elevation or depths are shown. *Mandatory flood insurance purchase requirements apply.*
Zone AE	SFHA subject to inundation by the 100-year flood determined in a Flood Insurance Study by detailed methods. Base flood elevations are shown within these zones. *Mandatory flood insurance purchase requirements apply.*
Zone X	These areas have been identified in the Flood Insurance Study as areas of moderate or minimal hazard from the principal source of flood in the area. However, buildings in these zones could be flooded by severe, concentrated rainfall coupled with inadequate local drainage systems. Local storm water drainage systems are not normally considered in the community's FIS. The failure of a local drainage system creates areas of high flood risk within these rate zones. *Flood insurance is available in participating communities, but is not required by regulation in these zones.*
Zone X500	The same description as Zone X, however, this area falls between the 100 and 500-year flood zone.
UNDES	Undescribed. No information available.
Zone Coastal A	

Under the NFIP regulations, participating NFIP communities are required to regulate all development in the SFHAs. Development is defined as:

> *"any man-made change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations or storage of equipment or materials."*

Before a property owner can undertake any development in the SFHA, a permit must be obtained from the locality. The locality is responsible for reviewing the proposed development to ensure that it complies with the locality's floodplain management ordinance. Localities are also required to review proposed developments in the SFHAs to ensure that all necessary permits have been received from those governmental agencies from which approval is required by Federal or State law, such as 404 Wetland Permits from the Army Corps of Engineers or permits under the Endangered Species Act.

Under the NFIP, localities must review all new development proposals to ensure that they are reasonably safe from flooding and that the utilities and facilities serving these developments are constructed to minimize or eliminate flood damage.

In general, the NFIP minimum floodplain management regulations require that new construction or substantial improvements to existing buildings in the Zone A must have their lowest floor, including basements, elevated to or above the Base Flood Elevation (BFE). Non-residential structures in Zone A can be either elevated or dry-flood proofed. In Zone V, the building must be elevated on piles/columns and the bottom of the lowest horizontal structural member of the lowest floor of all new construction or substantially improved existing buildings must be elevated to or above the BFE.

When the NFIP was created, the U.S. Congress recognized that insurance for "existing buildings" constructed before a community joined the Program would be prohibitively expensive if the premiums were not subsidized by the Federal Government. Congress also recognized that most of these flood-prone buildings were built by individuals who did not necessarily have sufficient knowledge of the flood hazard to make informed decisions.

Under the NFIP, "existing buildings" are generally referred to as pre-FIRM buildings. These buildings were built before the flood risk was known and identified on the locality's FIRM. Currently, about 26% of the 4.3 million NFIP policies in force are pre-FIRM subsidized policies as compared to 70% of the policies that were being subsidized in 1978 (FEMA 2002).

Middle Peninsula Flood Insurance Data

According to data from FEMA dated March 31, 2015 there are a total of 4,354 flood insurance policies covering Middle Peninsula properties. The following is a summary of flood insurance policy data by locality:

Table 16: Flood Insurance Policies within the Middle Peninsula (FEMA, 2015).

Locality	Total Policies	# of Claims Since 1978	Total Value of Claims
Essex	229	239	$6.197,534.36
Tappahannock	67	16	$193,571
Gloucester	1700	1339	$30,285,748.62
King & Queen	56	22	$584,113.30
King William	17	8	$158,306.60
West Point	100	76	$2,165,826.96
Mathews	1669	1179	$20,165,826.96
Middlesex	496	225	$2,943,857.77
Urbanna	20	12	$277,744.64
Totals	4354	3116	$63,427,187.64

Table 17: Repetitive Loss Properties in the Middle Peninsula *(Community Information System, 2008).*

County	# of Properties	# of Claims	Total Building Claims	Average Claim
Essex	25	63	$1,346,219	$21,368.56
Mathews	146	326	$6,470,833	$19,849.18

Gloucester	90	217	$4,591,533	$21,159.23
Middlesex	30	36	$485,801	$13,494.47
Town of Urbanna	2	4	$27,360	$6,840
Town of Tappahannock	2	4	$46,526	$11,631.50
Town of West Point	7	15	$463,417	$30,894.47

According to the Virginia Hazards Mitigation Plan repetitive loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978. Within the VDEM plan the National Flood Insurance Program identified claims over $1 million paid on RL with Middle Peninsula localities:

Table 18: NFIP claims of over $1 million paid on repetitive losses *(VDEM, 2013).*

Jurisdiction	Number of Properties as of 2008	Number of Properties as of 2011	Total Paid as of 2008	Total Paid as of 2011
Mathews County	119	143	$6,491,486	$7,126,599
Gloucester County	59	89	$3,404,953	$5,752,657
Essex County	32	26	$2,265,480	$1,594,119
Middlesex County	-	31	-	$1,063,094

4.4.5. Summer Storms

Summer Storms are weather systems accompanied by strong winds, lightning, heavy rain, and possibly hail and tornadoes. They can occur at any time in the Middle Peninsula of Virginia, although they are most frequent during the warm spring and summer months from April through September. The most common summer storm is the thunderstorm, with the severe thunderstorm with the most potential to cause damage. The potential thunderstorm threat is often measured by the number of "thunderstorm days" – defined as days in which thunderstorms are observed.

Thunderstorms form when a shallow layer of warm, moist air is overrun by a deeper layer of cool, dry air. Cumulonimbus clouds, frequently called "thunderheads," are formed in these conditions. These clouds are often enormous (up to six miles or more across and 40,000 to 50,000 feet high) and may contain tremendous amounts of water and energy. That energy is often released in the form of high winds, excessive rains, lightning, and possibly hail and tornadoes.

Thunderstorms are typically short-lived (often lasting no more than 30-40 minutes) and fast moving (30-50 miles per hour). Strong frontal systems, however, may spawn one squall line after another, composed of many individual thunderstorm cells. Severe thunderstorms may also cause severe flood problems because of the torrential rains that they may bring to an area. Thunderstorms sometimes move very slowly, and can thus dump a tremendous amount of precipitation onto a location. Flooding can result, including flash floods, "urban flooding," and river flooding.

4.5. Locality Specific Critical Facilities and Public Utilities

4.5.1. King and Queen County Critical Facilities and Public Utilities

The County's Courthouse Complex is located in the central portion of the county along the Route 14 ridgeline, which runs in a southeasterly/northwesterly direction. This Complex is the center of county government and contains all county offices. The law enforcement and public safety functions are located in the new courts/administration building, which has a generator that serves these areas of the building during a power outage. This complex is located outside of the 500-year floodplain.

Additional properties that the County owns include 4 solid waste facilities located at 4 different locations in the county and the property that the regional library is located on. All 5 of these properties lie outside of the 500-year floodplain.

There are 4 volunteer fire departments (VFD) and 2 volunteer rescue squads (VRS) located at scattered positions throughout the county. All of these emergency response facilities are located outside the 500-year floodplain.

The County's 3 school sites are all located along the high and dry Route 14/721 corridor. Central High School, located in the King and Queen Courthouse area in the middle portion of the county, is the County's designated shelter due to flooding or any other type of natural disaster.

The Middle Peninsula Regional Airport is located in the southern portion of the county and is owned and operated by a regional authority. The Airport Authority is made up of 4 local governments including King and Queen, King William and Gloucester Counties as well as the Town of West Point. Life-Evac, a medical transport helicopter service, is located at the airport. The airport terminal and runway are located outside the 500-year floodplain.

There are no public water or sewer facilities anywhere in the County - all properties in the County are served by individual wells and septic systems.

Repetitive and Severe Repetitive Loss Residential Structures in King and Queen County

There are no residential structures on FEMA's lists of Repetitive or Severe Repetitive Loss Properties as of 2011.

According to VDOT and County officials, flood prone roads in King and Queen County include the following:

Table 19: King and Queen County Flood Prone Roads

Route	Road Name	Location of Flooding
749	Kays Lane	at Root Swamp
721	Newtown Road	near Bradley Farm Road
721	Newtown Road	near Level Green Road
721	Newtown Road	near Cedar Plane Road
721	Newtown Road	near Glebe Road
623	Indian Neck Road	near Rappahannock Cultural Center
625	Poplar Hill Road	near Spring Cottage Road
628	Spring Cottage Road	near Eastern View Road
628	Todds Bridge Road	near Gunsmoke Lane

Route	Road Name	Location of Flooding
628	Pattie Swamp Road	at swamp
631	Fleets Mill Road	at Fleets Millpond
636	Minter Lane	at Walkerton Creek
631	Norwood Road	at Dickeys Swamp
620	Powcan Road	at Poor House Lane
634	Mt. Elba Road	at flat areas
620	Duck Pond Road	at Garnetts Creek
633	Mantua Road	at Garnetts Creek
617	Exol Road	at Exol Swamp
14	The Trail	at Truhart
614	Devils Three Jump Road	at Mt. Olive Road
613	Dabney Road	at Little Tastine Swamp
611	Tastine Road	at Little Tastine Swamp
603	Lombardy Road	at Little Tastine Swamp
608	Clancie Road	at Bugan Villa Drive
601	Stratton Major Road	near Union Prospect Baptist Church
601	Stratton Major Road	near Union Road
644	Jonestown Road	at Meadow Swamp
605	Plain View Lane	at Guthrie Creek
601	Cherry Row Lane	at Guthrie Creek and swamp
666	Tuckers Road	entire road including Tuckers R.P.
667	Wrights Dock Road	entire road
640	Lyneville Road	at 36" cross-pipes
625	Bryds Mill	at cross-pipes
615	Union Hope Road	at Exol Swamp
604	Bryds Bridge Road	at Bryds Bridge
612	Lilly Pond Road	at Dragons Swamp Bridge
610	Dragonville Road	at Timber Brook Swamp
614	Rock Springs Road	at bridge
14	Buena Vista Road	at K&Q/ Gloucester County line

Public Boat Ramps

There are 3 public boats ramps in the county along the Mattaponi River that are operated/maintained by the Virginia Department of Game and Inland Fisheries (VDGIF).

There is a relatively large facility at Walkerton at the base of the bridge that goes over the Mattaponi River. In addition, there are 2 small boat ramps – one at the end of State Routes 602, known as Melrose Landing and another one at the end of State Route 610, known as Waterfence Landing.

Due to the low velocity of the flood waters along this section of the Mattaponi River, none of these boat landings sustain damage from flood waters.

Properties in the 100-year Floodplain by Census Block Groups

The following series of maps show the location of structures in King and Queen County that are either in the Flood Zone A or in Flood Zone AE in the 100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 25:

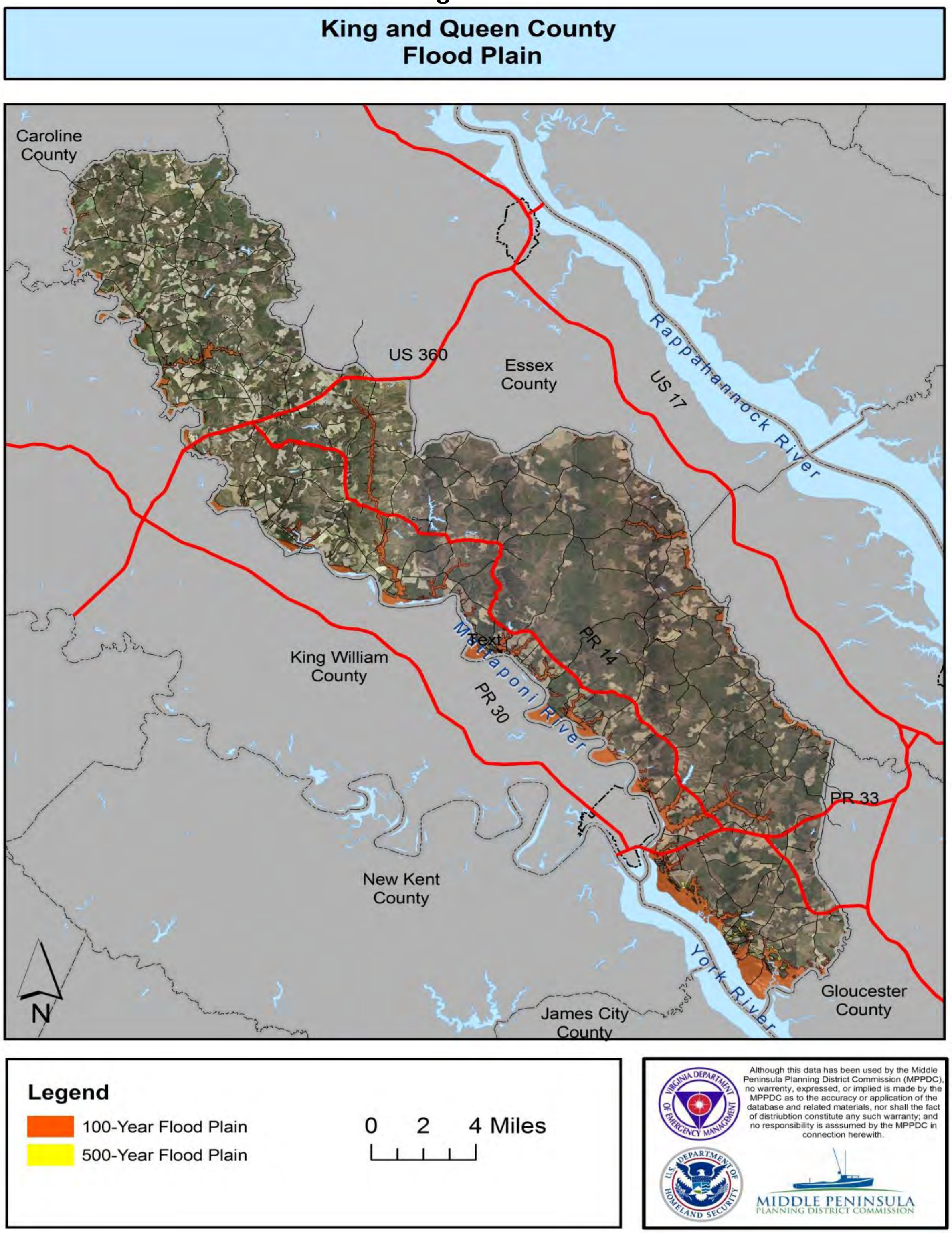
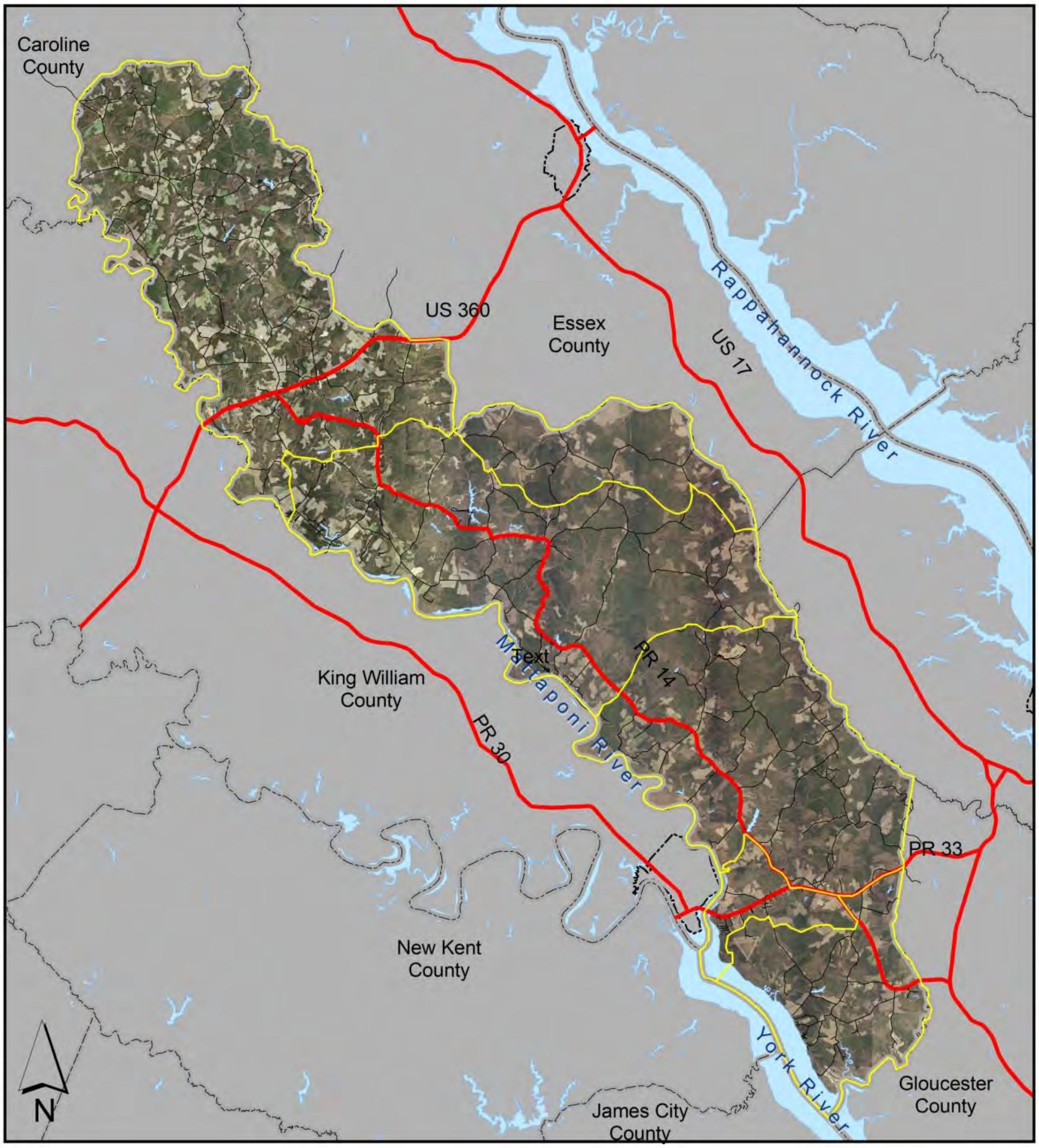

King and Queen County
Flood Plain
Caroline County
US 360
Essex County
Rappahannock River
US 17
King William County
Mattaponi River
Text
PR 14
PR 30
PR 33
New Kent County
York River
James City County
Gloucester County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 2 4 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 26:

King and Queen County Block Groups



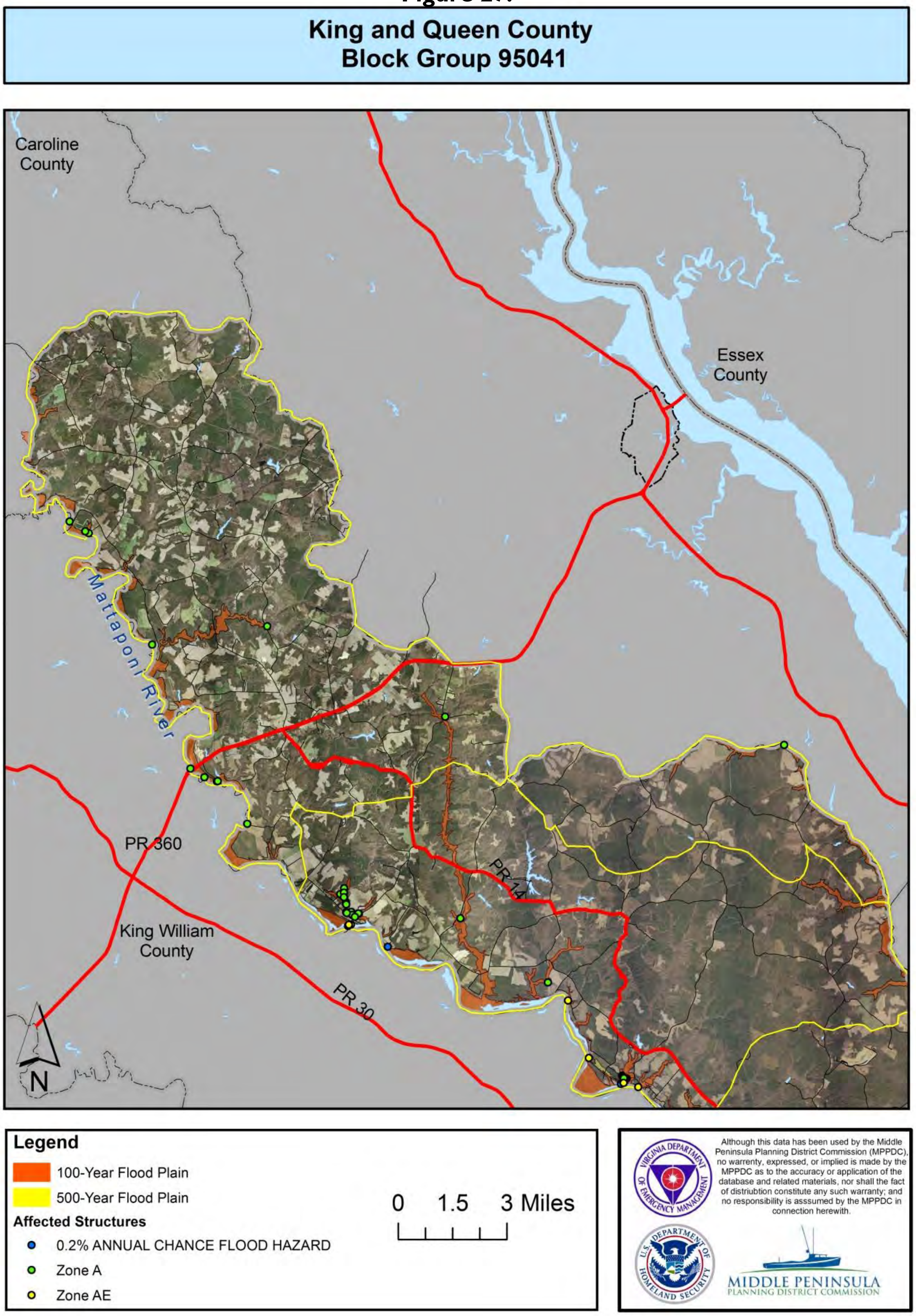
Legend

Census Block Groups

0 2 4 Miles

Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.

Figure 27:


King and Queen County
Block Group 95041
Caroline County
Essex County
Mattaponi River
PR 360
PR 14
King William County
PR 30
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 1.5 3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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PLANNING DISTRICT COMMISSION

Figure 28:

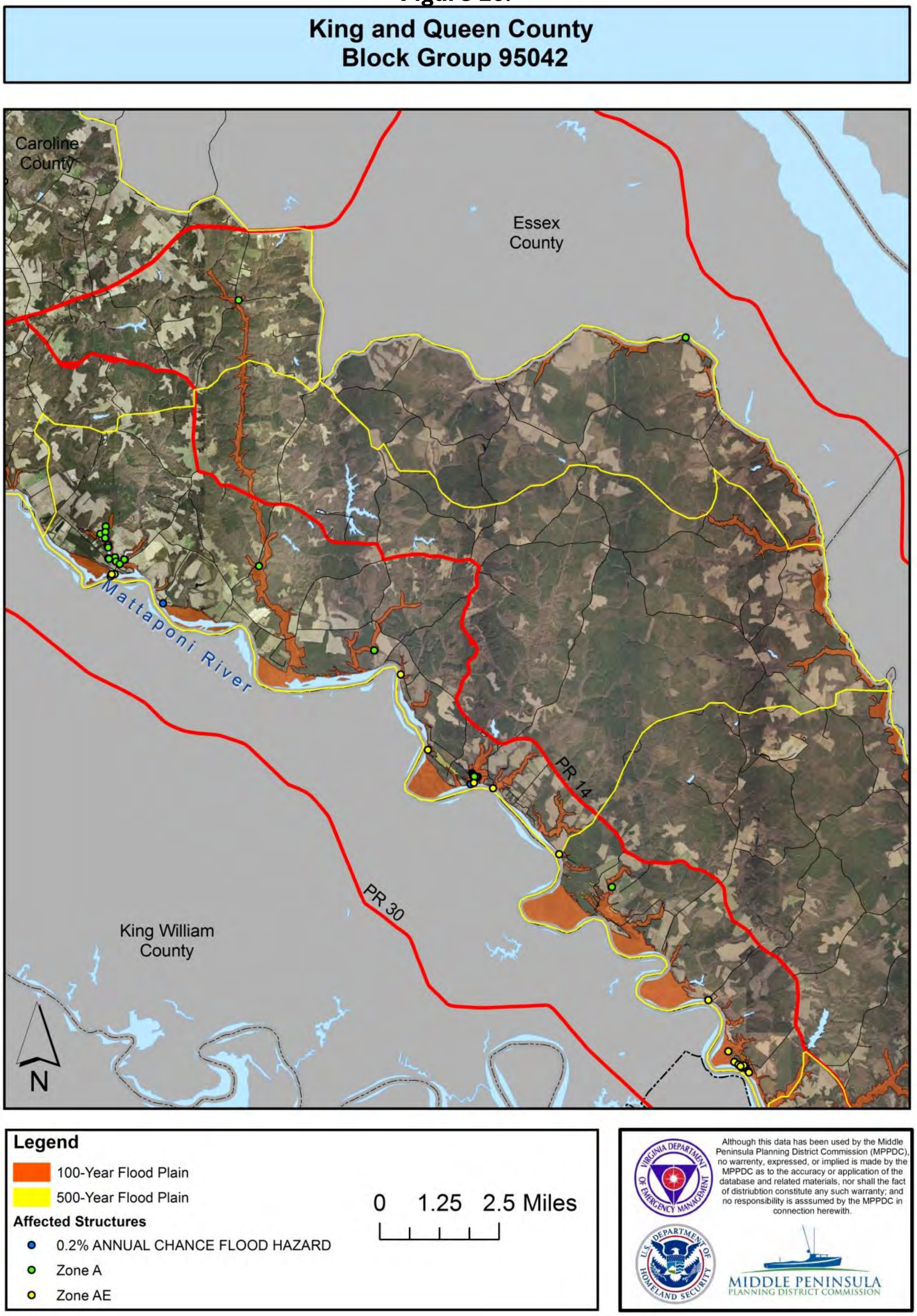
King and Queen County
Block Group 95042
Caroline County
Essex County
Mattaponi River
PR 14
PR 30
King William County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 1.25 2.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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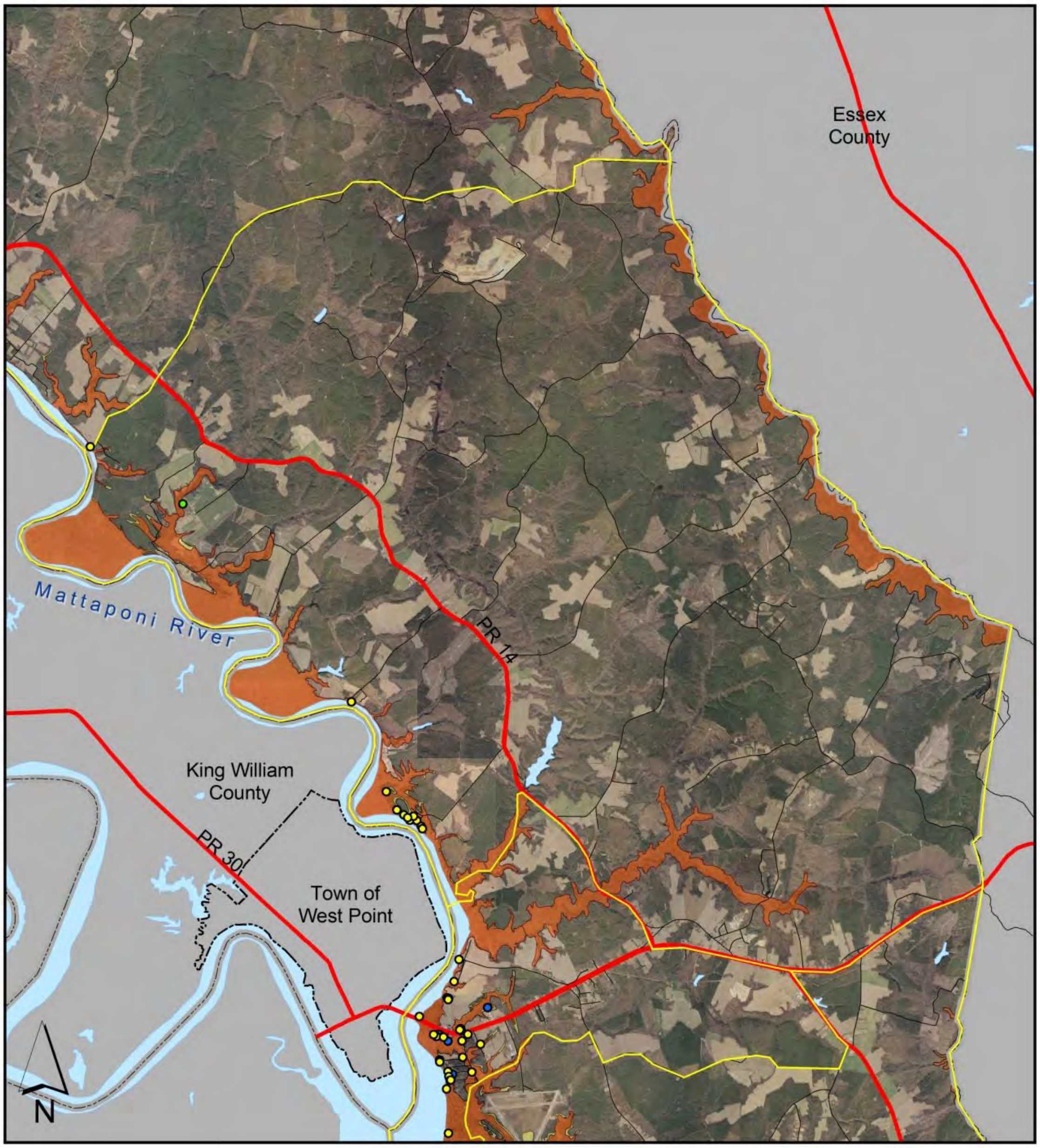
Figure 29:

King and Queen County
Block Group 95051



Legend

- 100-Year Flood Plain
- 500-Year Flood Plain

Affected Structures

- 0.2% ANNUAL CHANCE FLOOD HAZARD
- Zone A
- Zone AE

0 0.5 1 Miles

Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.

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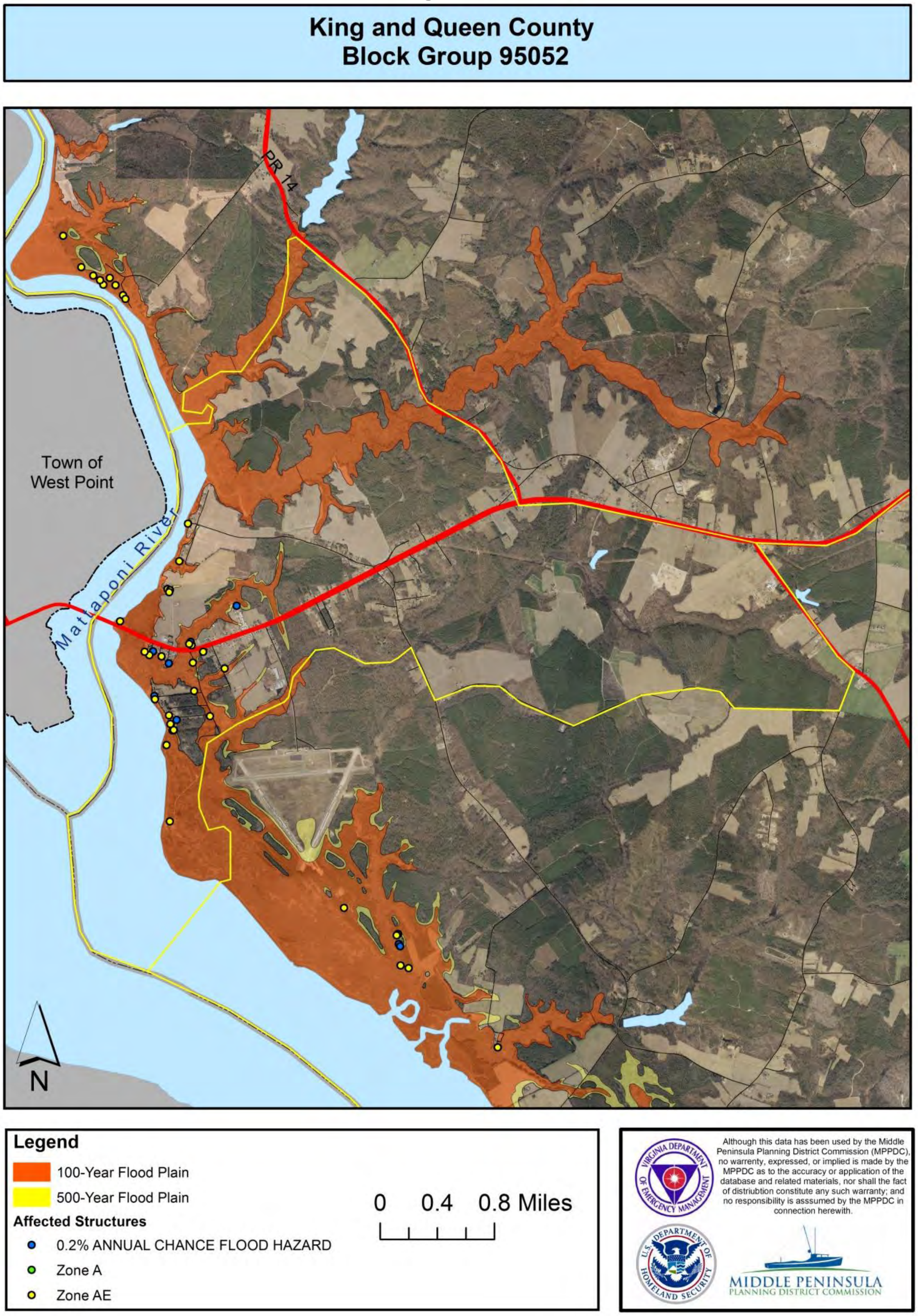
Figure 30:


King and Queen County
Block Group 95052
PR 14
Town of
West Point
Mattaponi River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 0.4 0.8 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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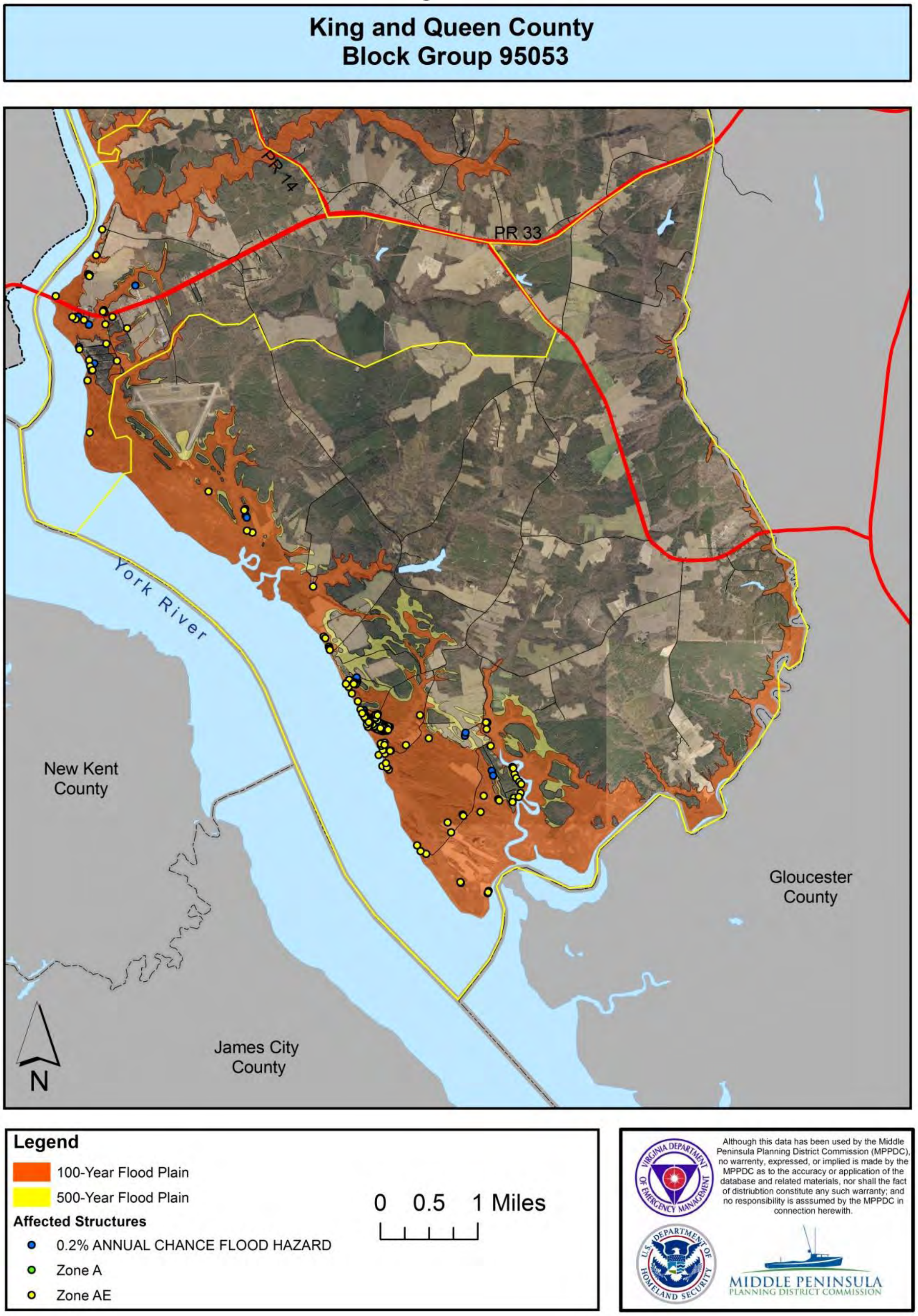
PLANNING DISTRICT COMMISSION

Figure 31:


King and Queen County
Block Group 95053
PR 14
PR 33
York River
New Kent County
James City County
Gloucester County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
0.2% ANNUAL CHANCE FLOOD HAZARD
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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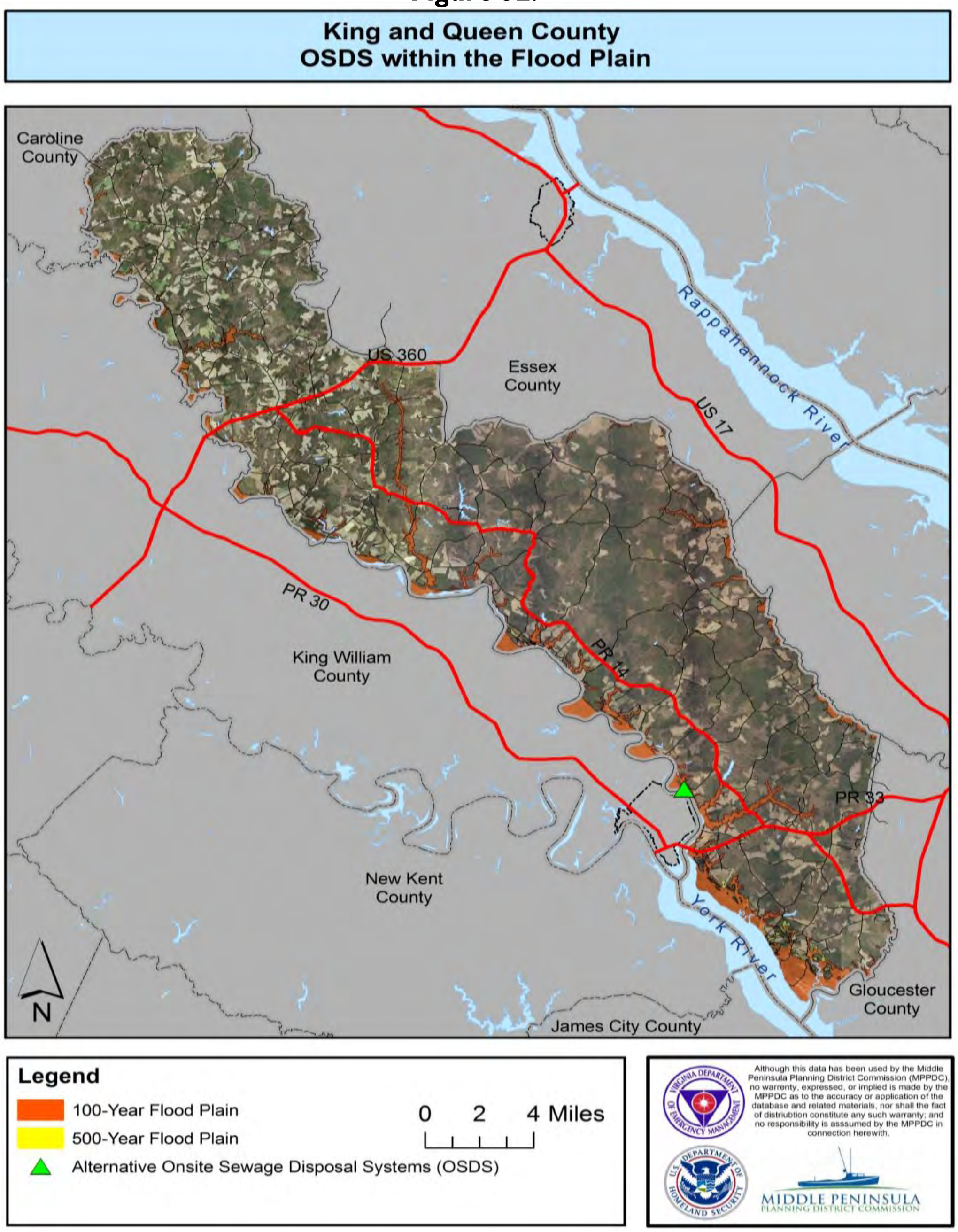
Alternative On-site Sewage Disposal Systems (OSDS)

The Virginia Department of Health regulations have changed dramatically in recent years to keep pace with improvements in technology. Now, there are a number of what are termed "alternative on-site sewage disposal systems" that are allowed to be constructed where poor soils and/or a high water table prevented the construction of a conventional septic system on the property. As of 2009, there were 1,208 OSDSs permitted and installed in the Middle Peninsula. There are an additional 2,006 OSDSs permitted by the health department, but not yet installed.

Many of these are located in the 100-year floodplain, some of which could suffer damage during flooding events since most of the systems have essential mechanical and other components at-grade or slightly above grade.

Figure 32:



4.5.2. Essex County Critical Facilities and Public Utilities

The County's Offices are located within the Town of Tappahannock, which is centrally located mid-county along the Route 17 corridor. The County Offices are located in a handful of buildings in downtown Tappahannock in an area that is outside of the 500-year floodplain. There are emergency generators at the County Administration Building and at the Sheriff's Office/Dispatch Center.

Route 17 is the main south/north road serving the county. This primary road has been designated as a hurricane evacuation route by the Commonwealth of Virginia for some Tidewater residents evacuating northward during a Category 2 or stronger hurricane. However, a portion of Route 17 on the north side of Tappahannock (near the June Parker Marina) floods on a regular basis during storms of minor to moderate intensity. Plans to alleviate this bottleneck during flood-prone times have been proposed by town and county officials to VDOT, but road improvement plans remain on the drawing board due to a lack of VDOT/Federal funding for this project.

Additional properties that the County owns includes 2 solid waste facilities located at Center Cross and Bray's Fork, the county library, the elementary school/school board offices and the middle school/high school complex. All of these properties are located outside of the 500-year floodplain. The new middle school has an emergency generator.

The county/town is served by 1 volunteer fire department that has 3 fire stations. One station is located in Tappahannock along Airport Road, another is located at the northern end of the county along Route 17 at Loretto and the third station is located at the southern end of the County near Center Cross. The Tappahannock Volunteer Rescue Squad is located in downtown Tappahannock and it serves town residents as well as all county residents. All of these emergency response facilities are located outside of the 500-year floodplain. The fire department on Airport Road and the EMS facility downtown have emergency generators.

The new Tappahannock-Essex County Community Airport is located off of Route 360 at Paul's Crossroads. The airport is located on a high ridge-line, which is obviously outside of the 500-year floodplain.

The new animal shelter that serves the town and county is located at the town's former maintenance facility along Airport Road, which does not flood.

Tappahannock Critical Facilities and Public Utilities

The Town of Tappahannock provides public water and sewer services to its citizens. The water system does not sustain damage during floods.

The wastewater treatment plant is located along Hoskins Creek on the west side of Route 17. The wastewater treatment plant does not suffer damage during severe flooding events. However, there is one sewerage pump station located along Newbill Drive that does receive flood damage during hurricane strength storms. The damage occurs to the electrical controls at this pump station site. During Hurricane Isabel in 2003, the electrical controls needed to be repaired. In addition, Newbill Drive does suffer roadway damage and soil erosion during severe storms.

Repetitive and Severe Repetitive Loss Residential Structures in Tappahannock

According to FEMA's records, there are 26 residential properties on the Repetitive Loss and the Severe Repetitive Loss Lists in Essex County in addition to 2 properties in Tappahannock as of 5/31/10.

Properties in the 100-year Floodplain by Census Block Groups
The following series of maps show the location of structures in Essex County that are either in the Flood Zone A or in Flood Zone AE in the 100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 33:

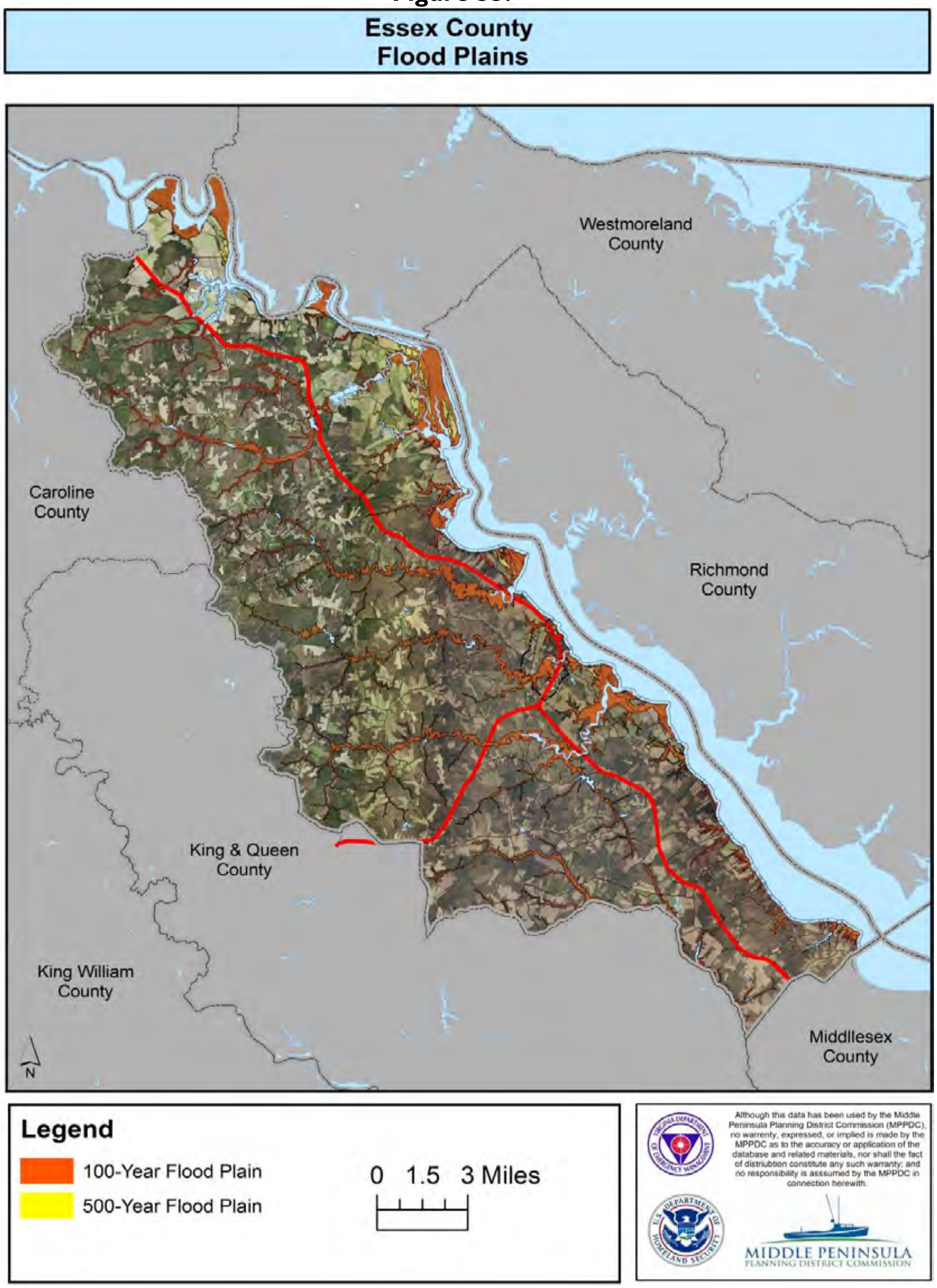
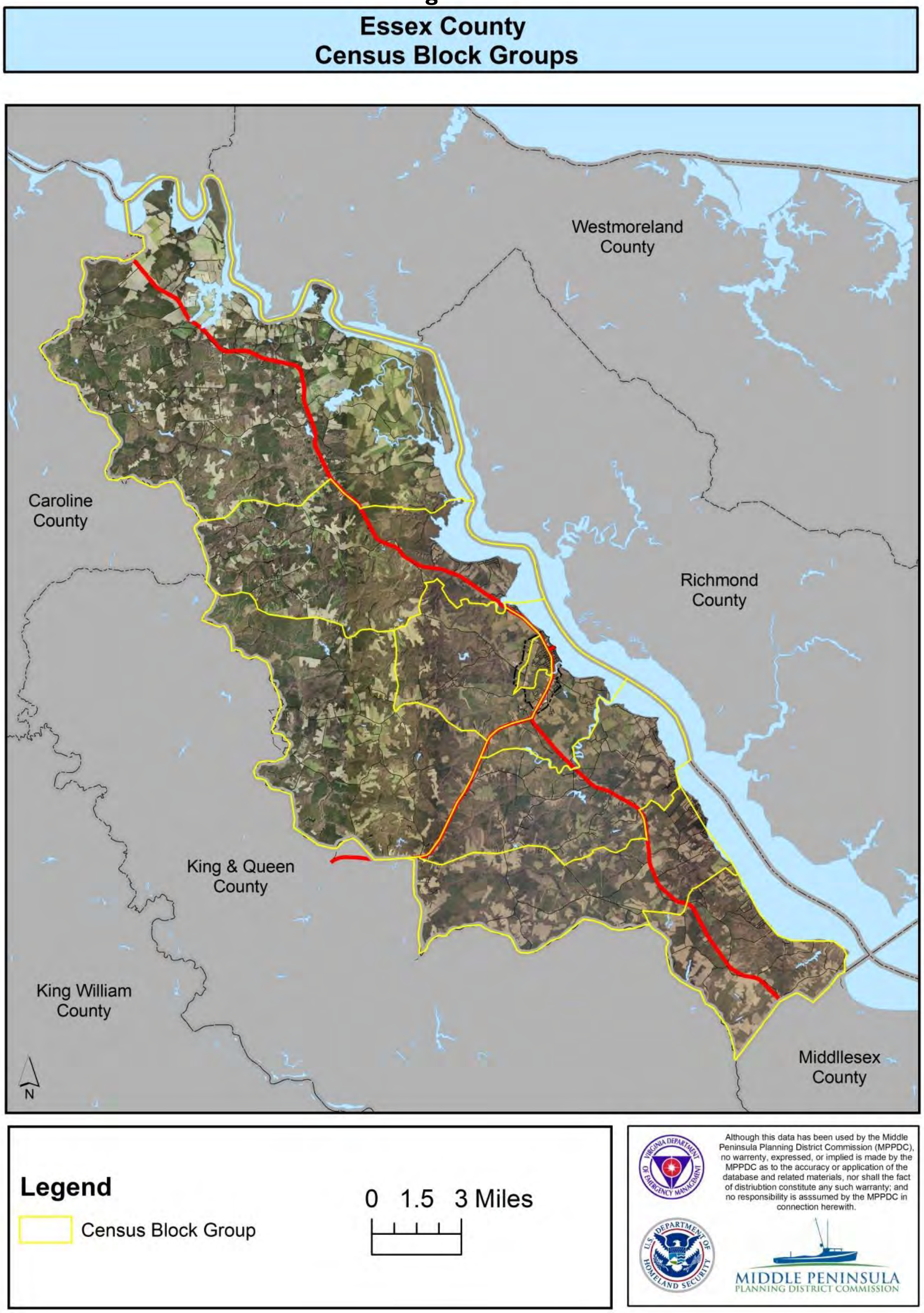


Figure 34:


Essex County
Census Block Groups
Westmoreland County
Caroline County
Richmond County
King & Queen County
King William County
Middllesex County
N
Legend
Census Block Group
0 1.5 3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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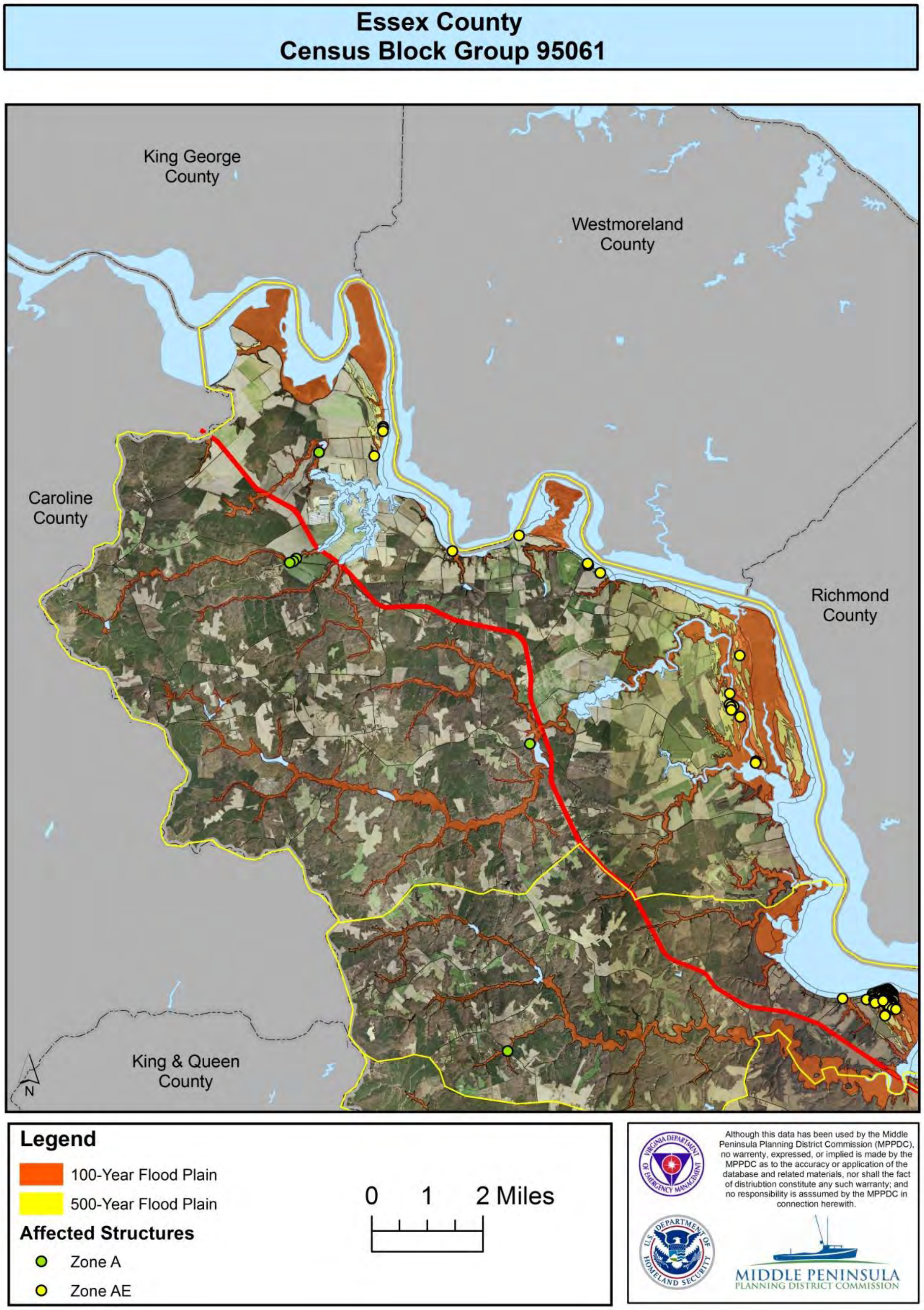
PLANNING DISTRICT COMMISSION

Figure 35:



Essex County
Census Block Group 95061
King George County
Westmoreland County
Caroline County
Richmond County
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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PLANNING DISTRICT COMMISSION

Figure 36:

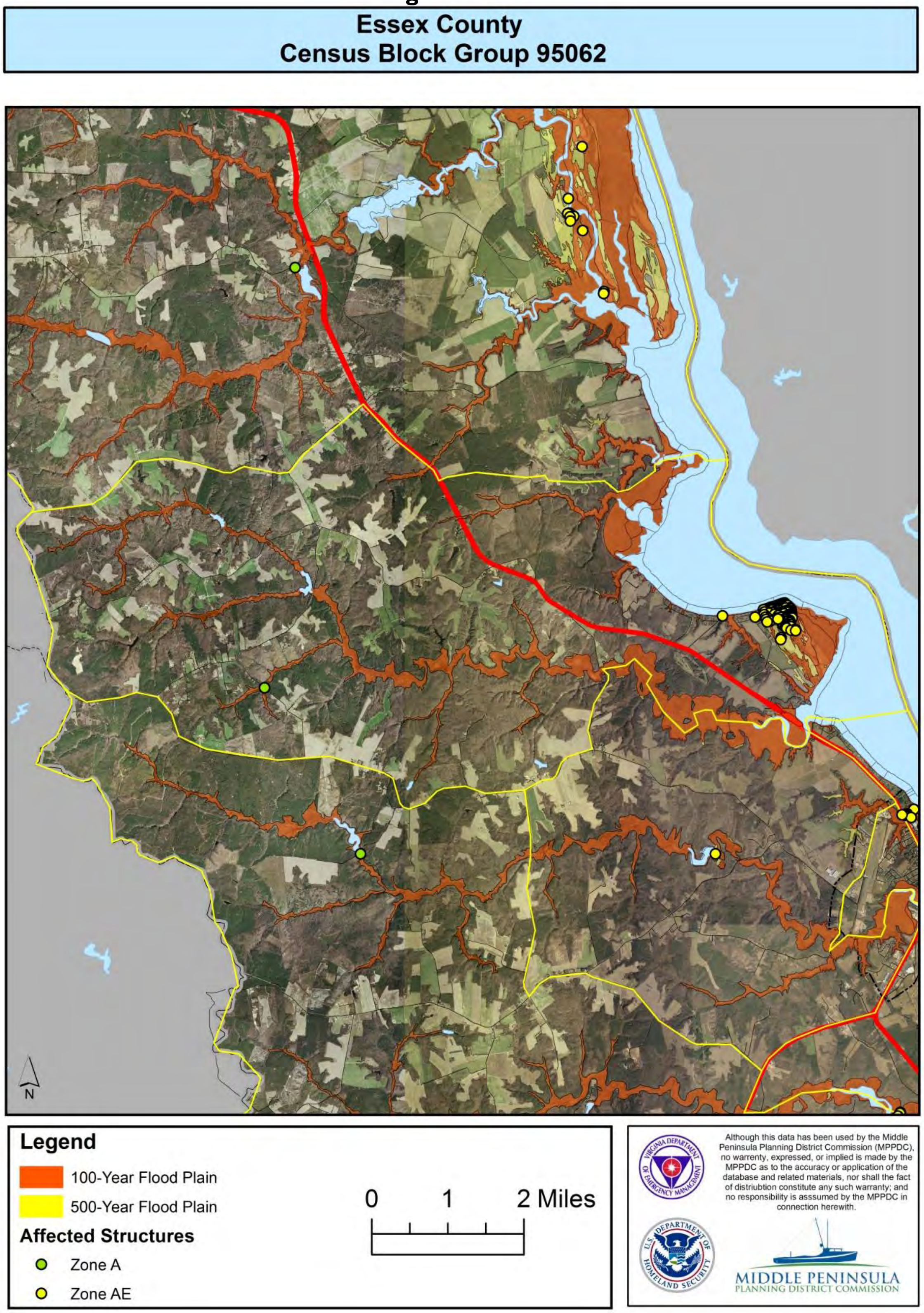
Essex County
Census Block Group 95062
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 37:

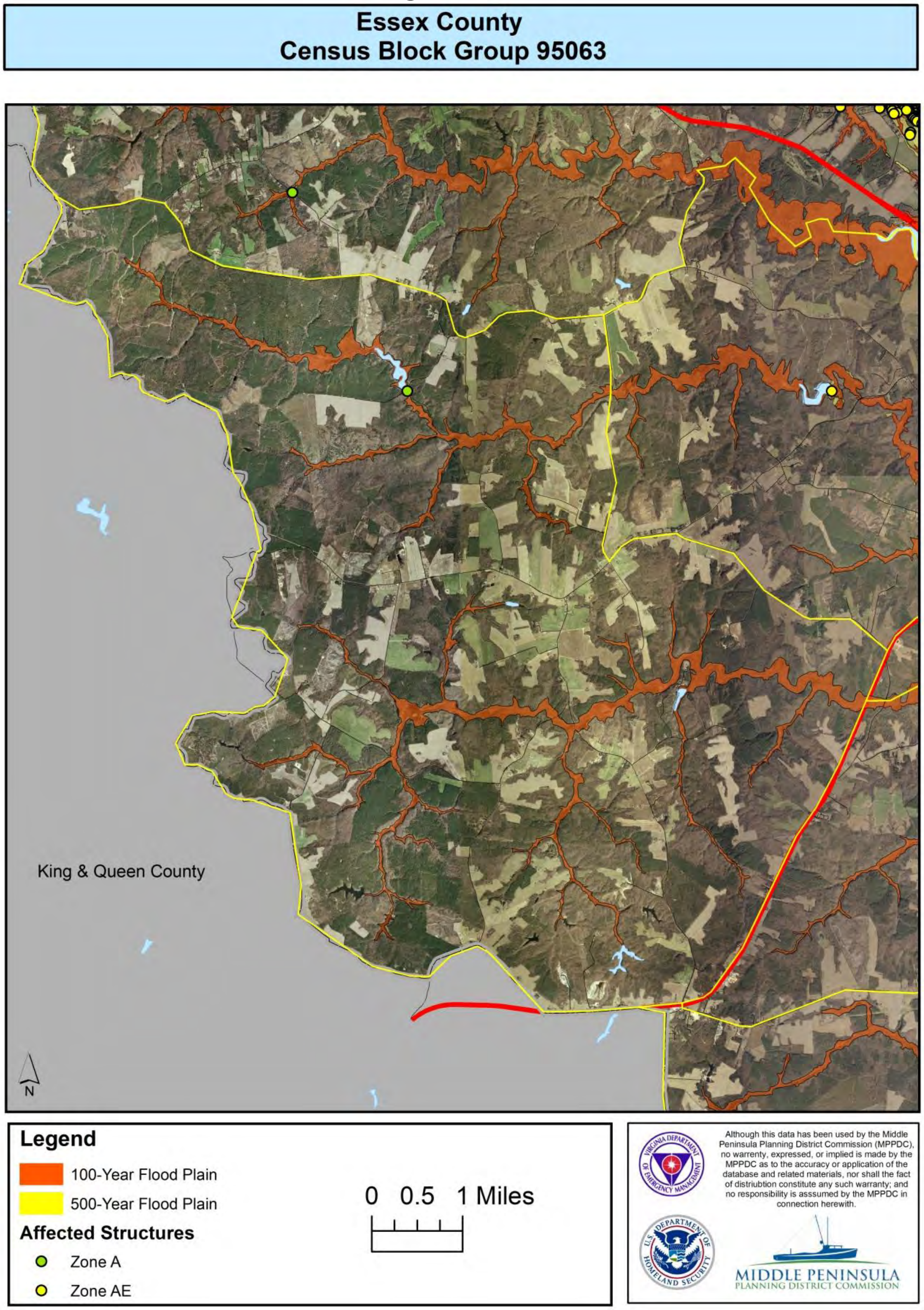
Essex County
Census Block Group 95063
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 38:

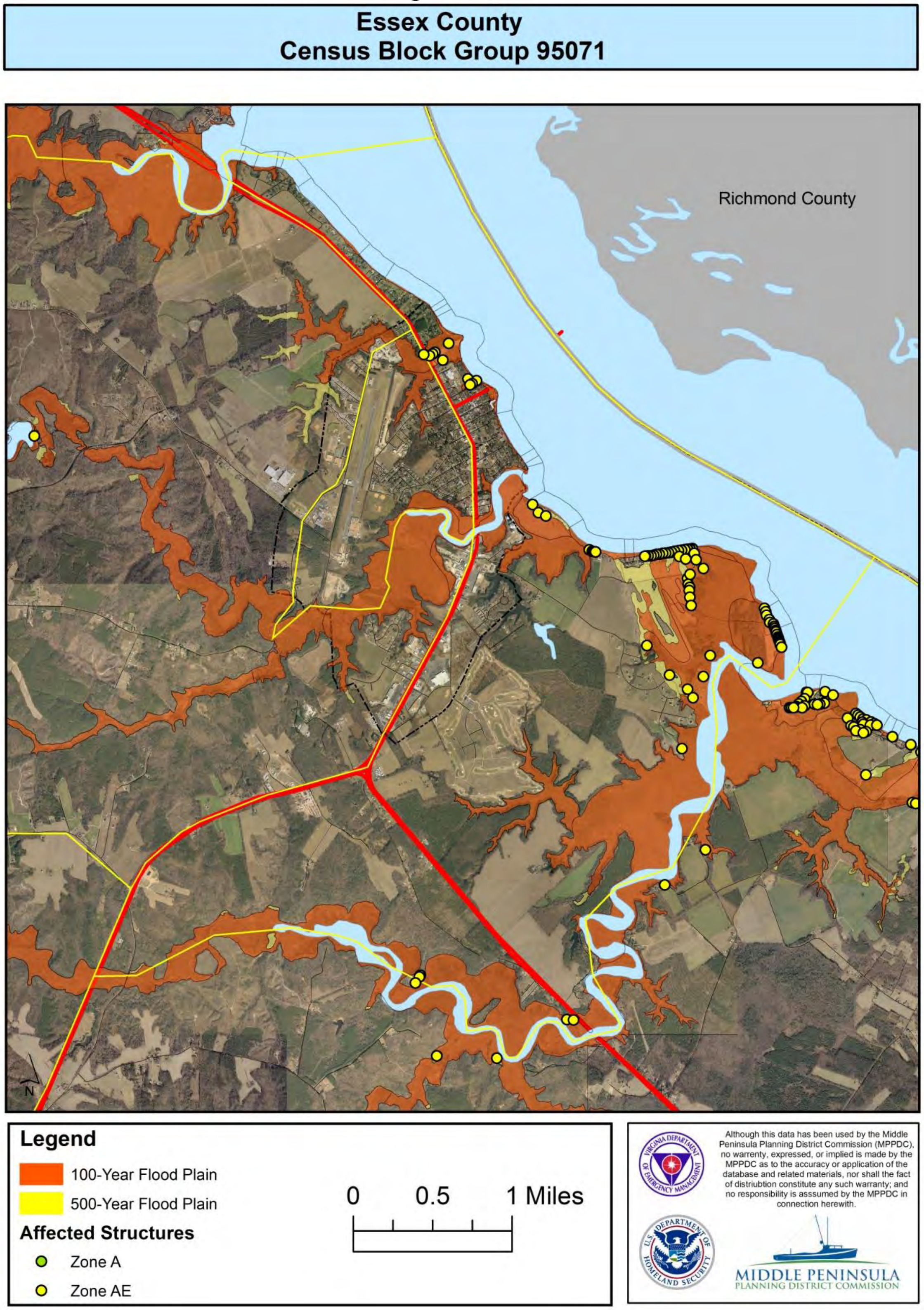
Essex County
Census Block Group 95071
Richmond County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 39:

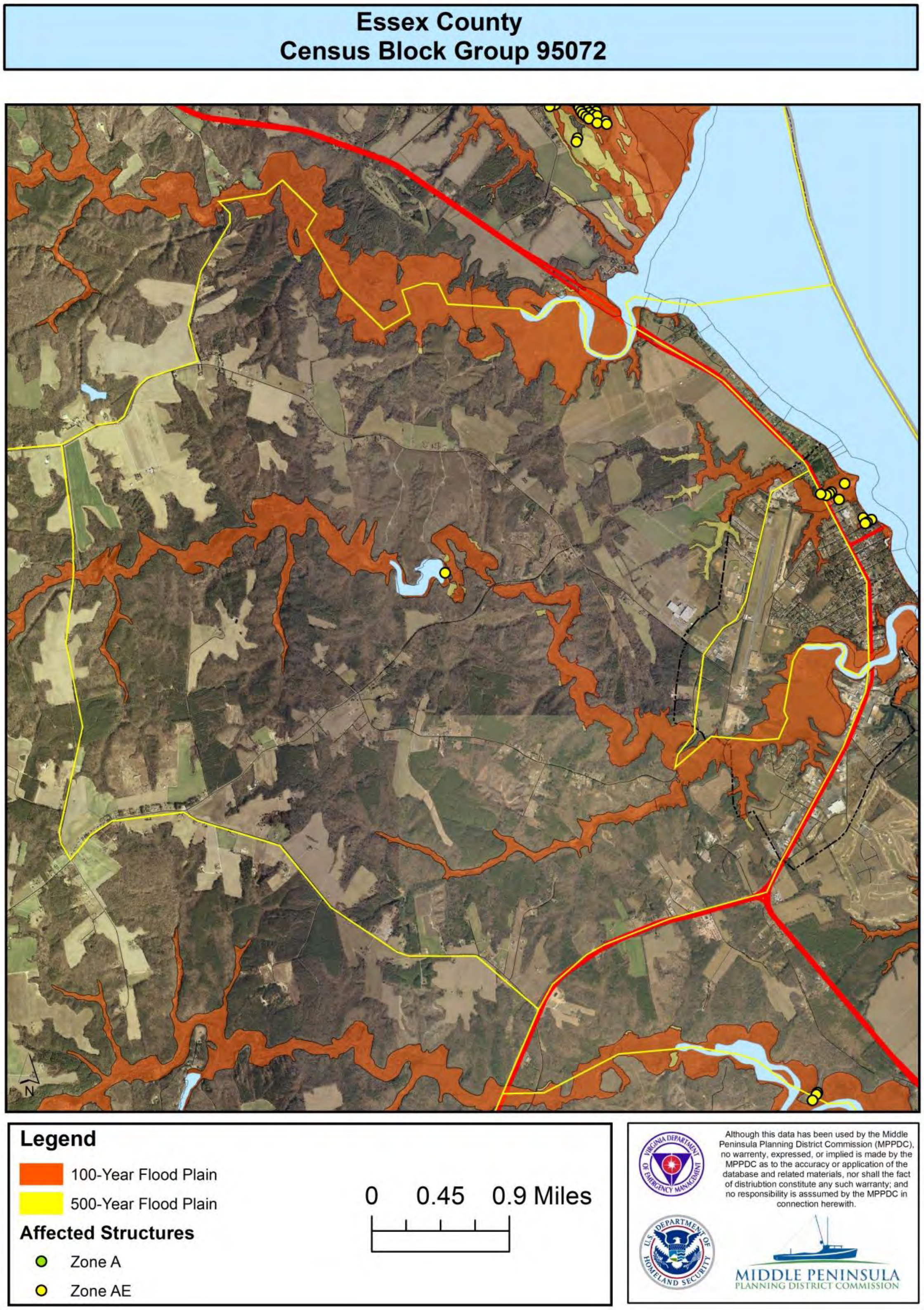
Essex County
Census Block Group 95072
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.45 0.9 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

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Figure 40:

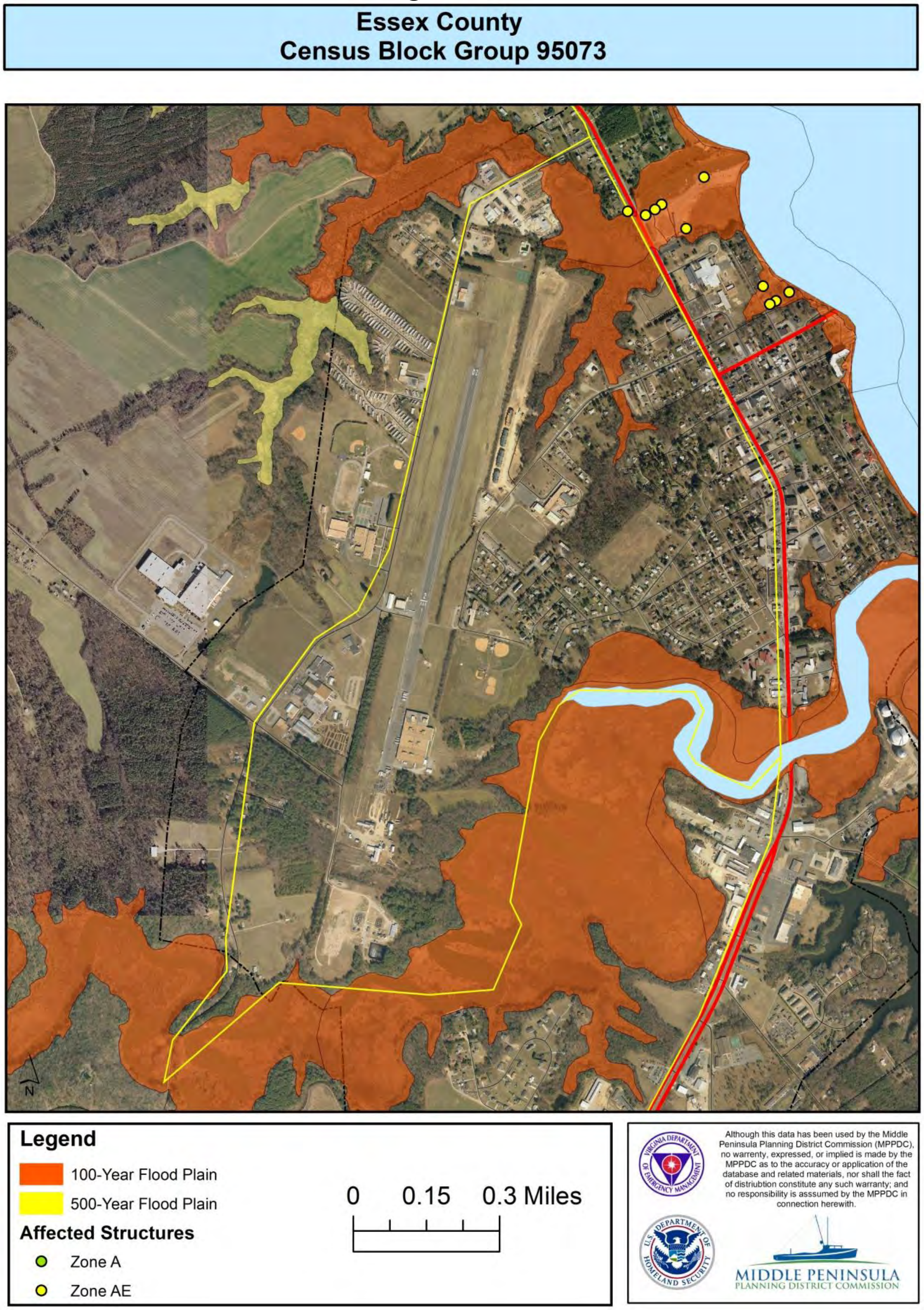
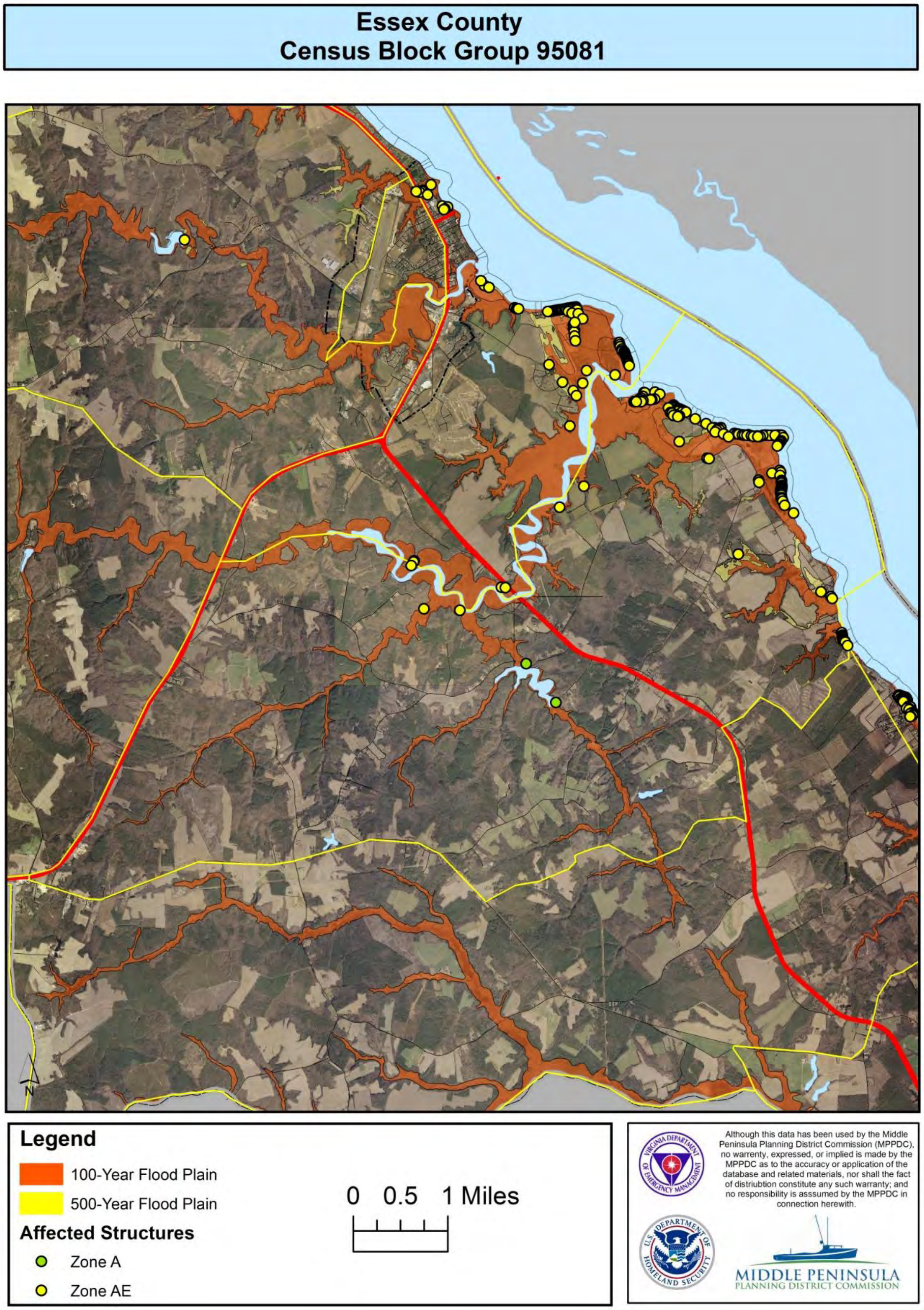


Figure 41:


Essex County
Census Block Group 95081
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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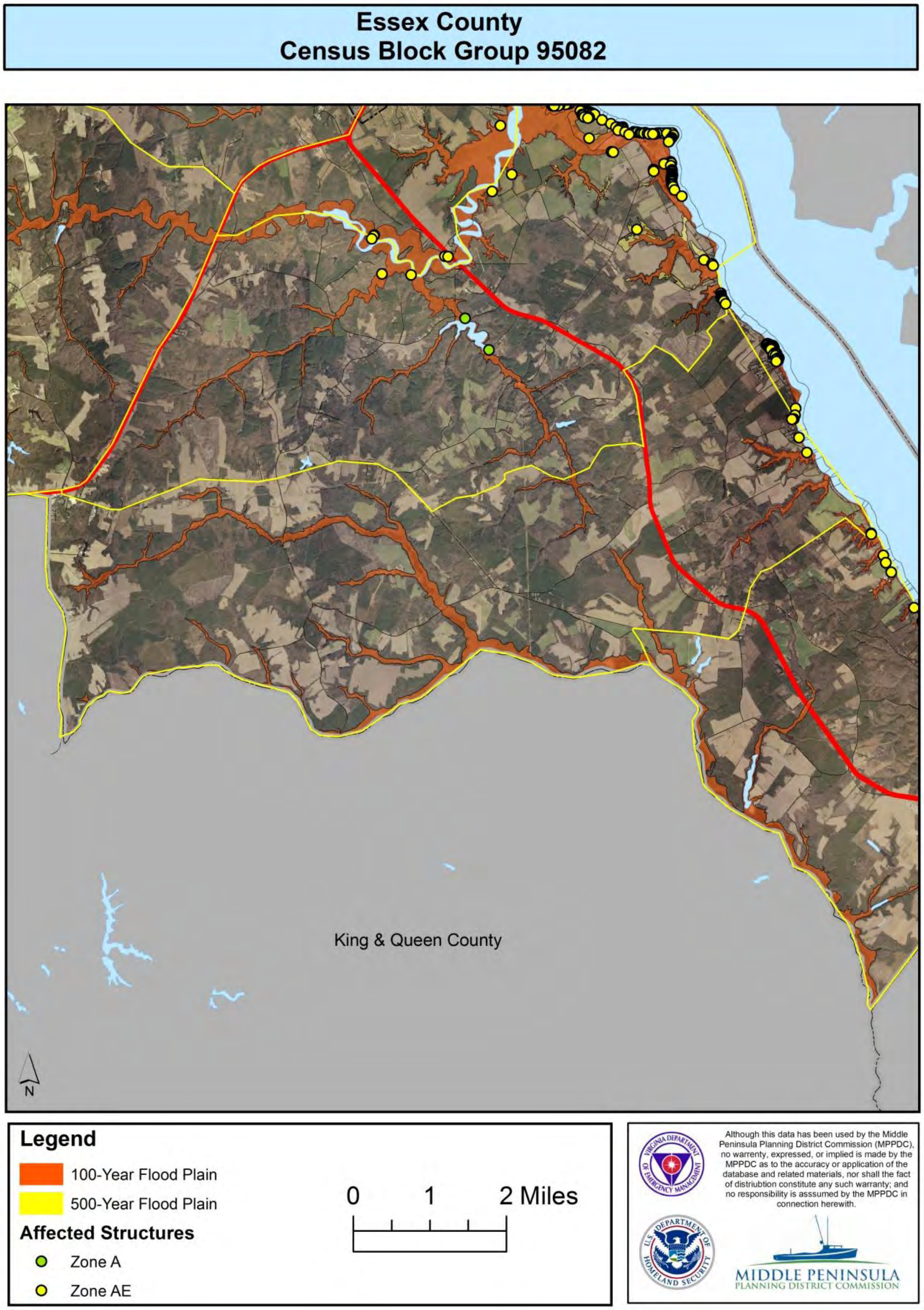
PLANNING DISTRICT COMMISSION

Figure 42:


Essex County
Census Block Group 95082
King & Queen County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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PLANNING DISTRICT COMMISSION

Figure 43:


Essex County
Census Block Group 95083
King & Queen County
MIddlesex County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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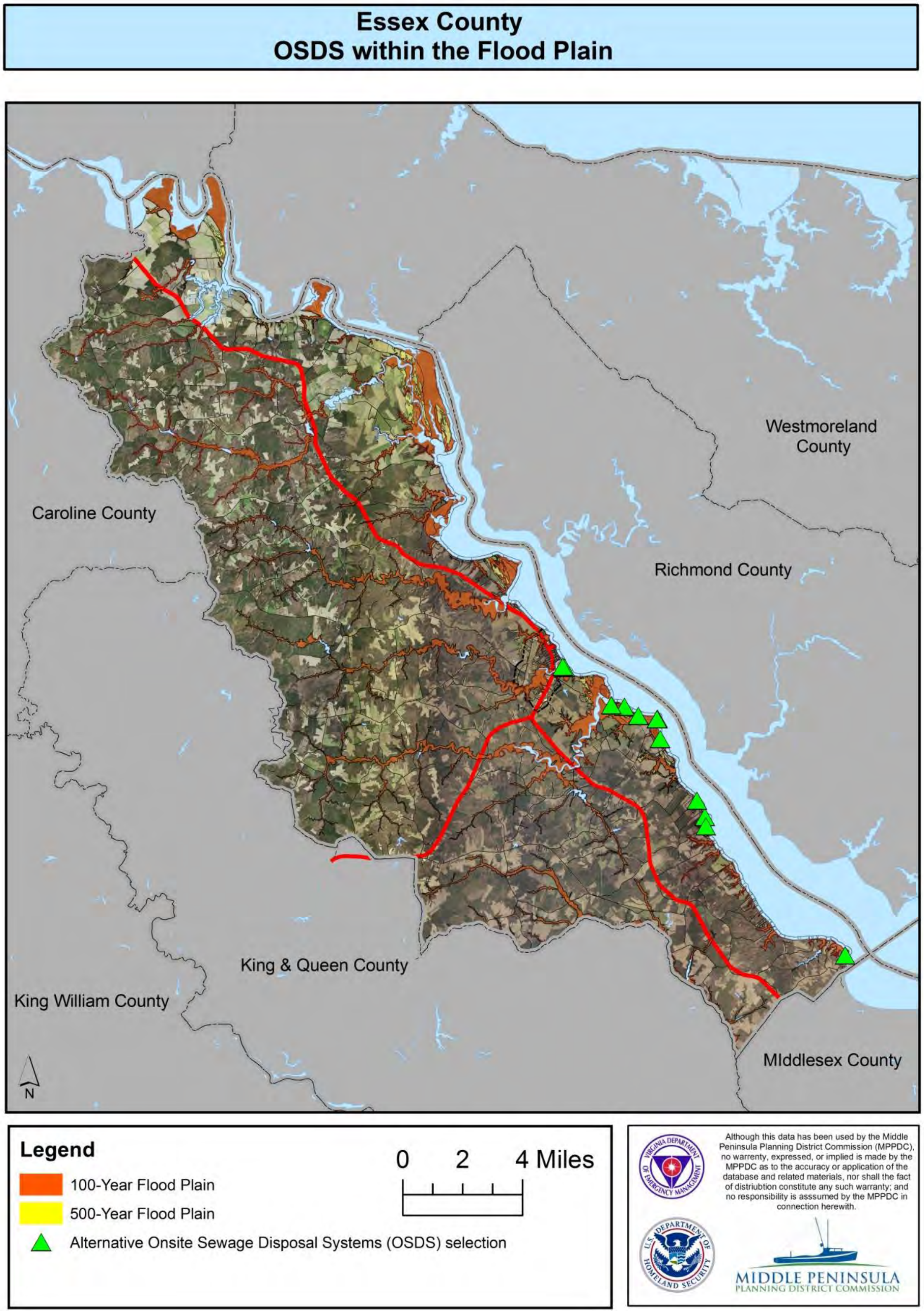
PLANNING DISTRICT COMMISSION

Alternative On-site Sewage Disposal Systems (OSDS). The following maps show the location of the OSDS systems constructed in the 100-year and 500-year floodplain in Essex County:

Figure 44:



According to VDOT officials, flood prone roads in the Essex County/Tappahannock area include the following:

Table 14: Essex/Tappahannock Flood Prone Roads		
Route	**Road Name**	**Location**
17	Church Lane	Tickners Creek at June Parker Marina
617	Island Farm Road	Piscataway Creek
646	Fort Lowery Lane	Rappahannock River
680	River Place	Rappahannock River

According to town officials, all of the roads that dead end at the Rappahannock River do flood, but sustain little damage since flood velocities are low along this section of the river through Tappahannock.

Public Boat Landings

There are 2 public boat landings located in Tappahannock along the Rappahannock River. The boat landing at Prince Street is owned and operated by VDOT. The road at this boat landing does suffer minor damage during severe storm events. The boat landing at Dock Street is owned by the Town of Tappahannock and operated by the Virginia Department of Games of Inland Fisheries. This boat landing does not sustain damage from flood waters according to town officials.

4.5.3. King William County Critical Facilities and Public Utilities

Public water and sewerage systems serve portions of the Route 360 growth corridor in Central Garage. A package wastewater treatment plant discharges sewer effluent into an unnamed tributary that leads into Moncuin Creek, which then flows into the Pamunkey River. Floodwaters do not adversely impact the wastewater treatment plant.

The public water system serves the relatively high and dry Central Garage area. Therefore, this Route 360/30 area water system does not sustain damage from flooding events.

According to VDOT officials, flood prone roads in the King William County/West Point area include the following:

Table 15. King William County/West Point Flood Prone Roads		
Route	**Road Name**	**Location**
30	King William Road	Cypress Swamp at Olson's Pond
636	VFW Road	Cypress Swamp
632	Mt. Olive- Cohoke Road	Intersection of Route 633
609	Smokey Road	Herring Creek
628	Dorrel Road	Herring Creek
1006	Thompson Ave	West Point Creek
1003	Chelsea Road	West Point Creek to dead end
1130	Glass Island Road	Mattaponi River
1107	Kirby Street	1st to 7th Streets
n/a	1st to 7th Streets	Between Kirby St. and Pamunkey River
n/a	2nd to 5th Streets	Between Lee St. and Mattaponi River

Public Boat Landings

There are 2 public boat ramps along the Mattaponi River in King William County. There is a very small canoe/kayak launce at Zoar State Forest located a few miles north of Route 360. There is a larger boat ramp in Aylett immediately south of Route 360 with a ramp and a fishing dock.

Due to the low velocity of the flood waters along these upper reaches of the Mattaponi River, neither of these boat landings sustain damage from flood waters.

Repetitive and Severe Repetitive Loss Residential Structures in King William County

There are no residential structures on FEMA's lists of Repetitive or Severe Repetitive Loss Properties as of 5/31/10.

Properties in 100-year Floodplain by Census Block Group

The following series of maps show the location of structures in King William County that are either in the Flood Zone A or in Flood Zone AE in the 100-year flood plain. The map also shows structures in the 500-year plain that are labeled: "0.2% annual chance flood hazard". The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 45:

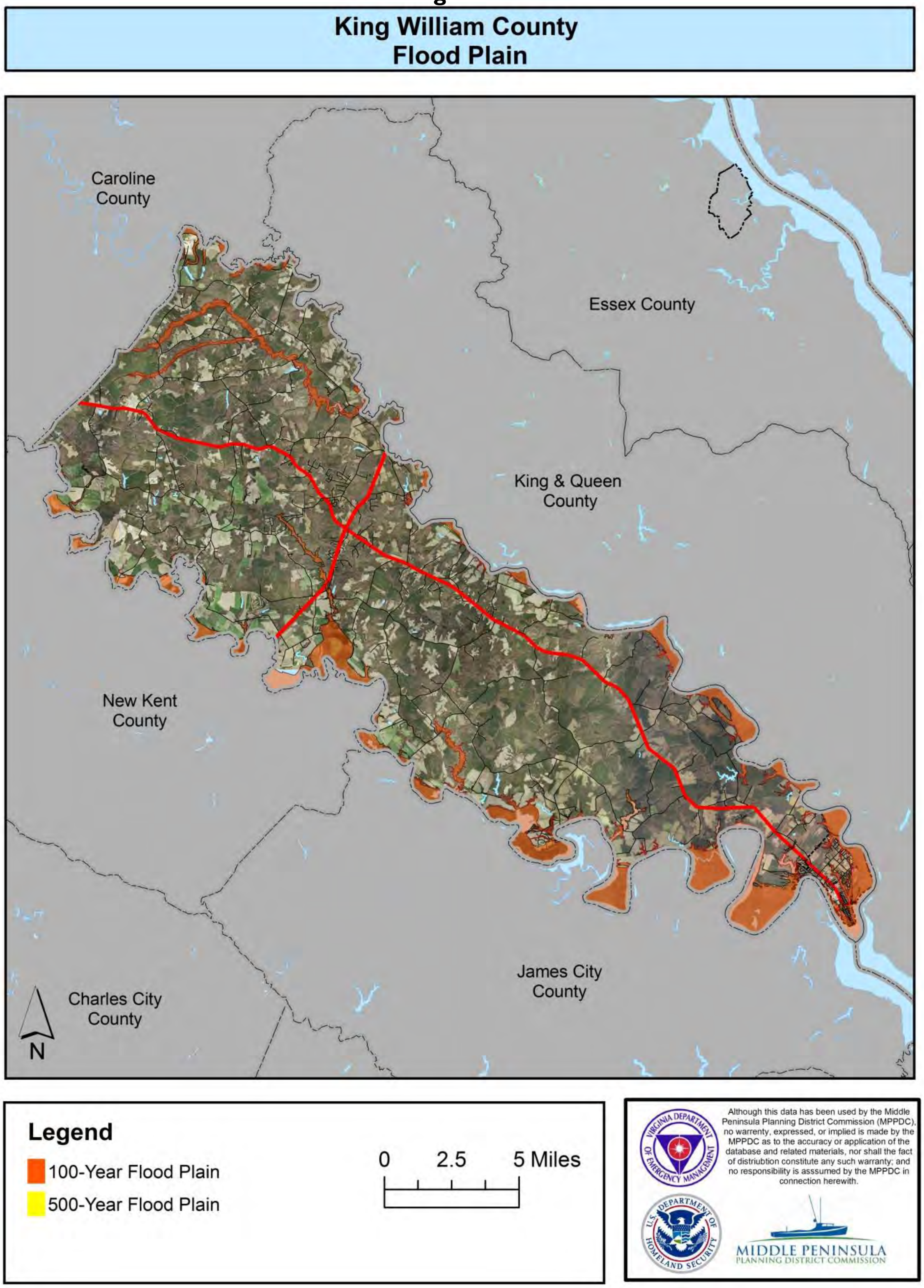

King William County
Flood Plain
Caroline County
Essex County
King & Queen County
New Kent County
James City County
Charles City County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0
2.5
5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 46:

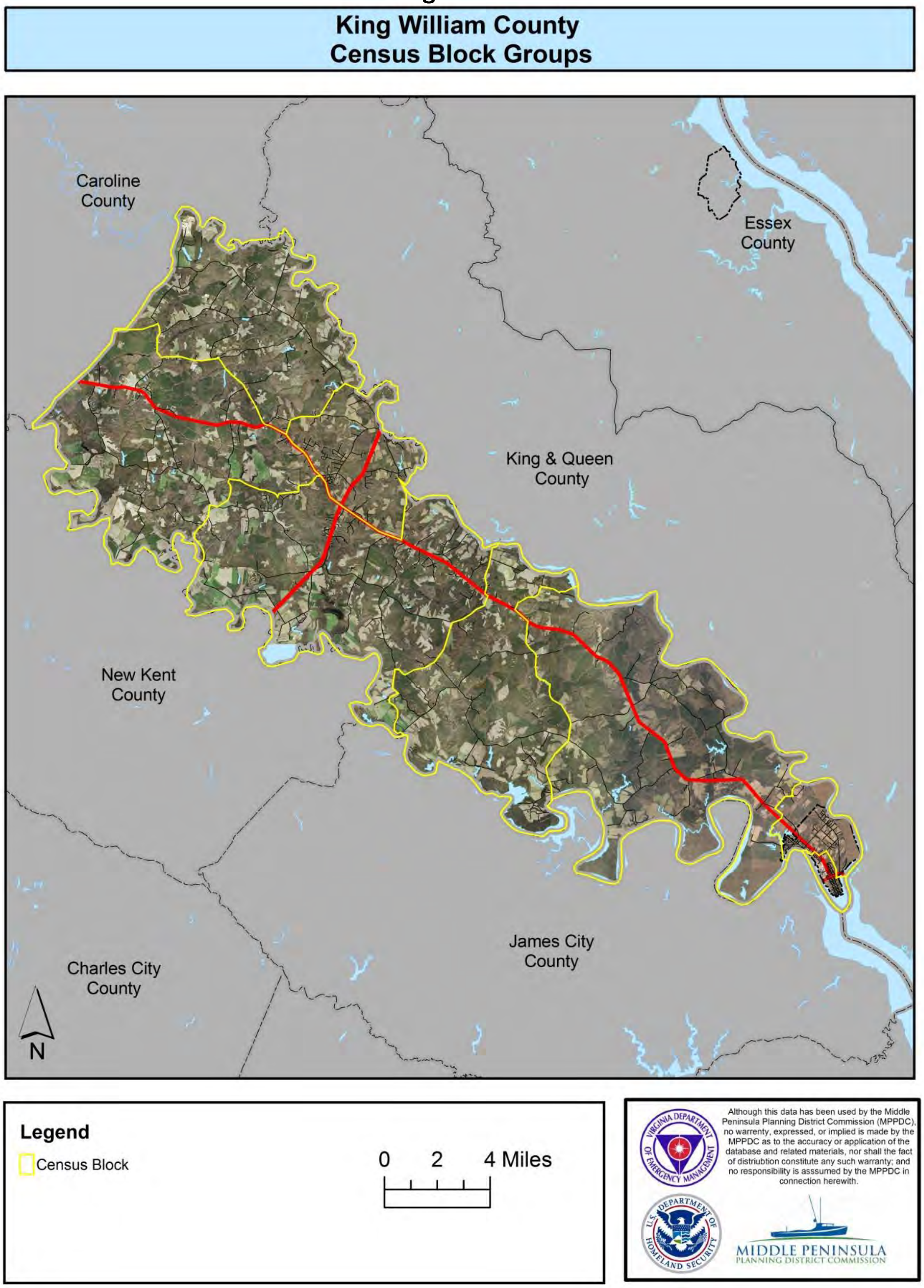

King William County
Census Block Groups
Caroline County
Essex County
King & Queen County
New Kent County
James City County
Charles City County
N
Legend
Census Block
0 2 4 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 47:

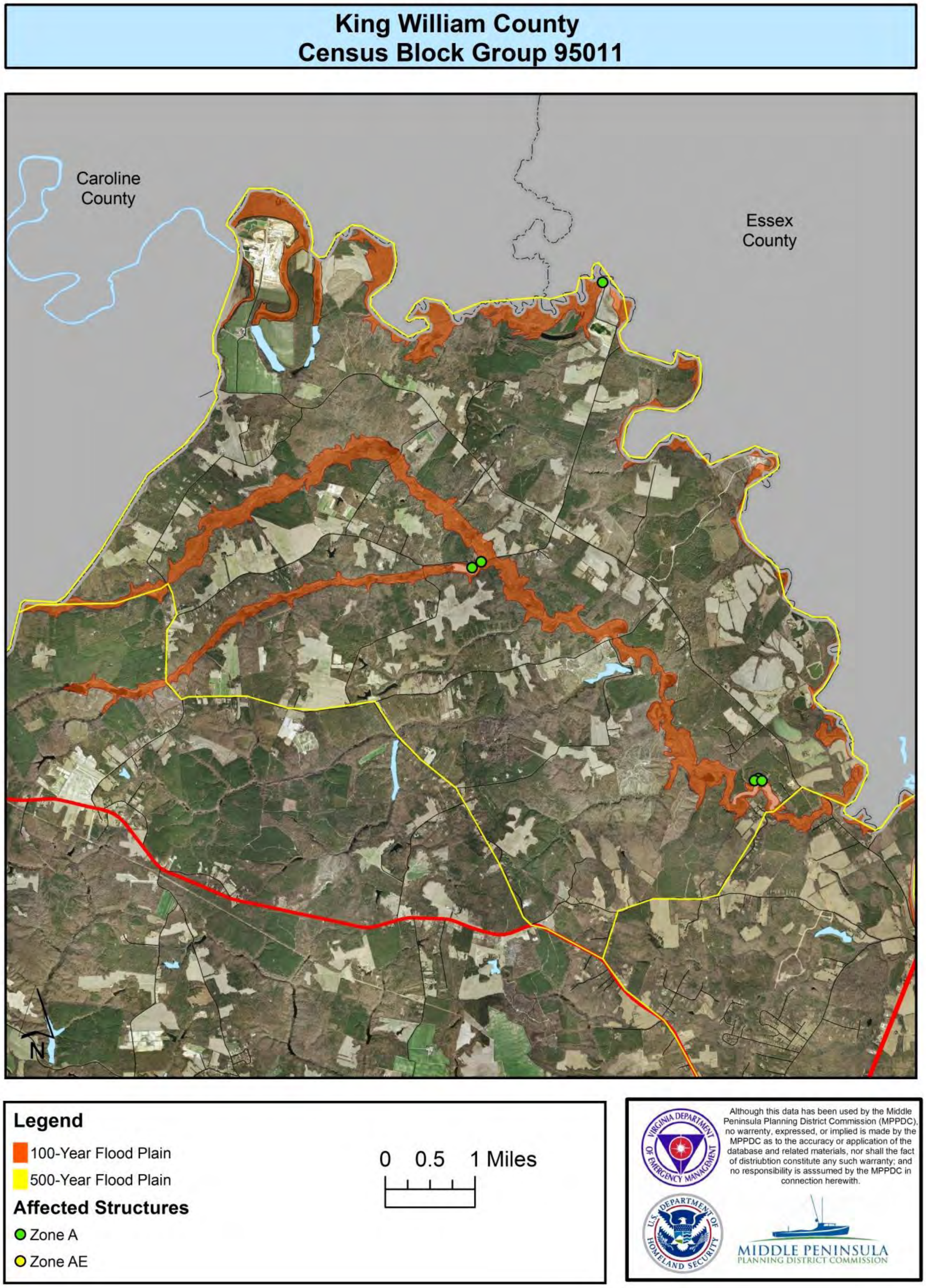

King William County
Census Block Group 95011
Caroline County
Essex County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 48:

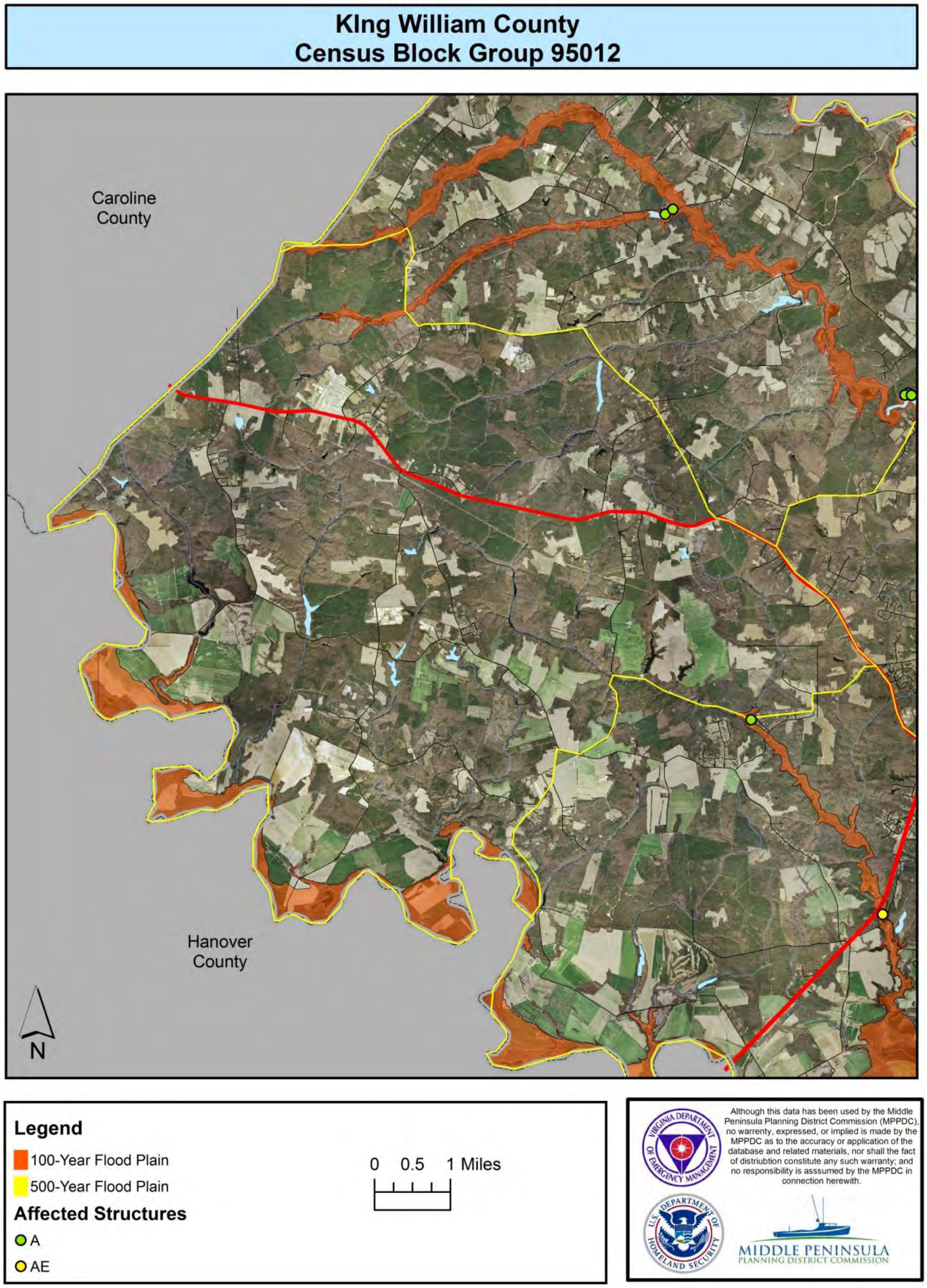
KIng William County
Census Block Group 95012
Caroline County
Hanover County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.

Figure 49:

Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.

Figure 50:

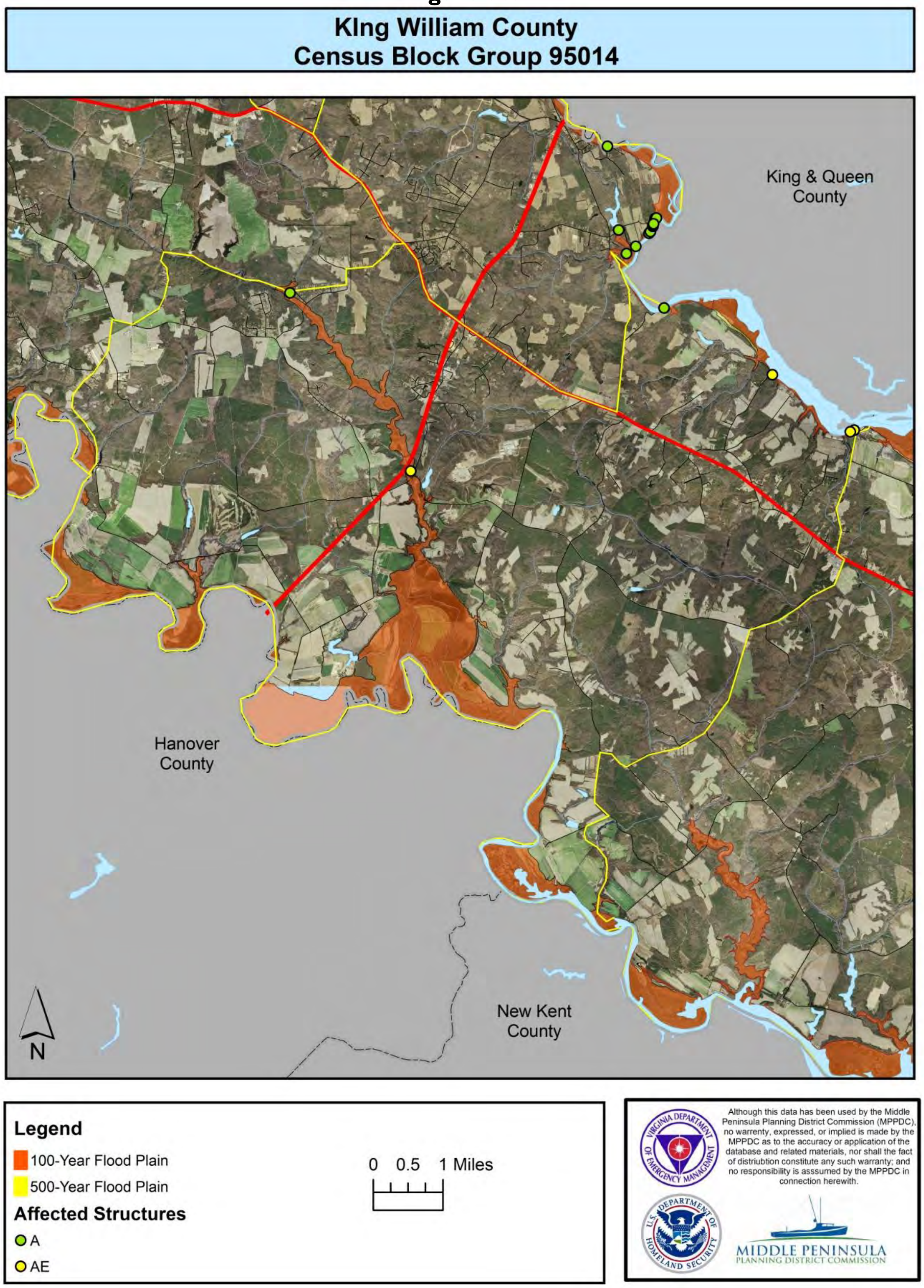
KIng William County
Census Block Group 95014
King & Queen County
Hanover County
New Kent County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 51:


KIng William County
Census Block Group 95021
King & Queen County
Hanover County
New Kent County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.45 0.9 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 52:

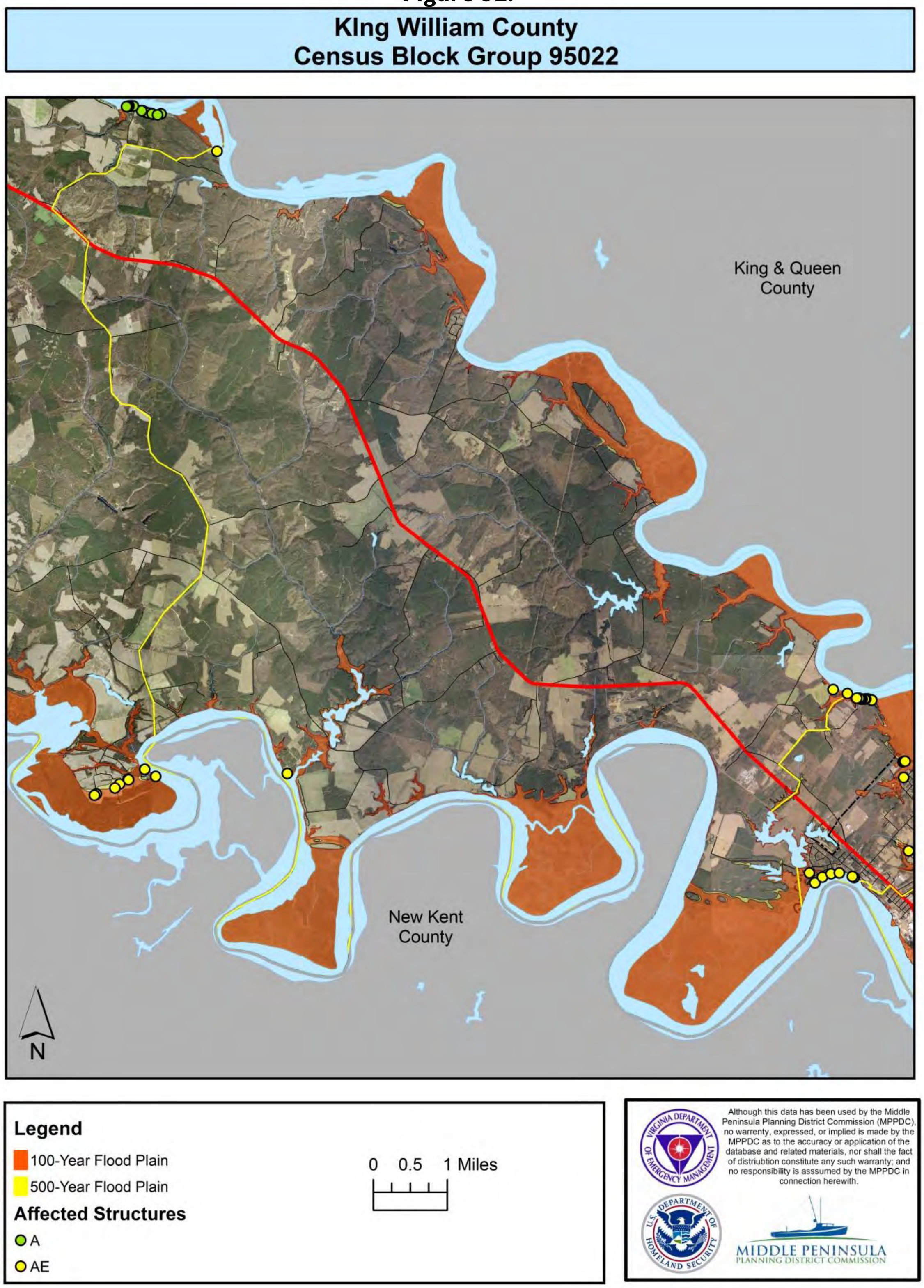
KIng William County
Census Block Group 95022
King & Queen County
New Kent County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 53:

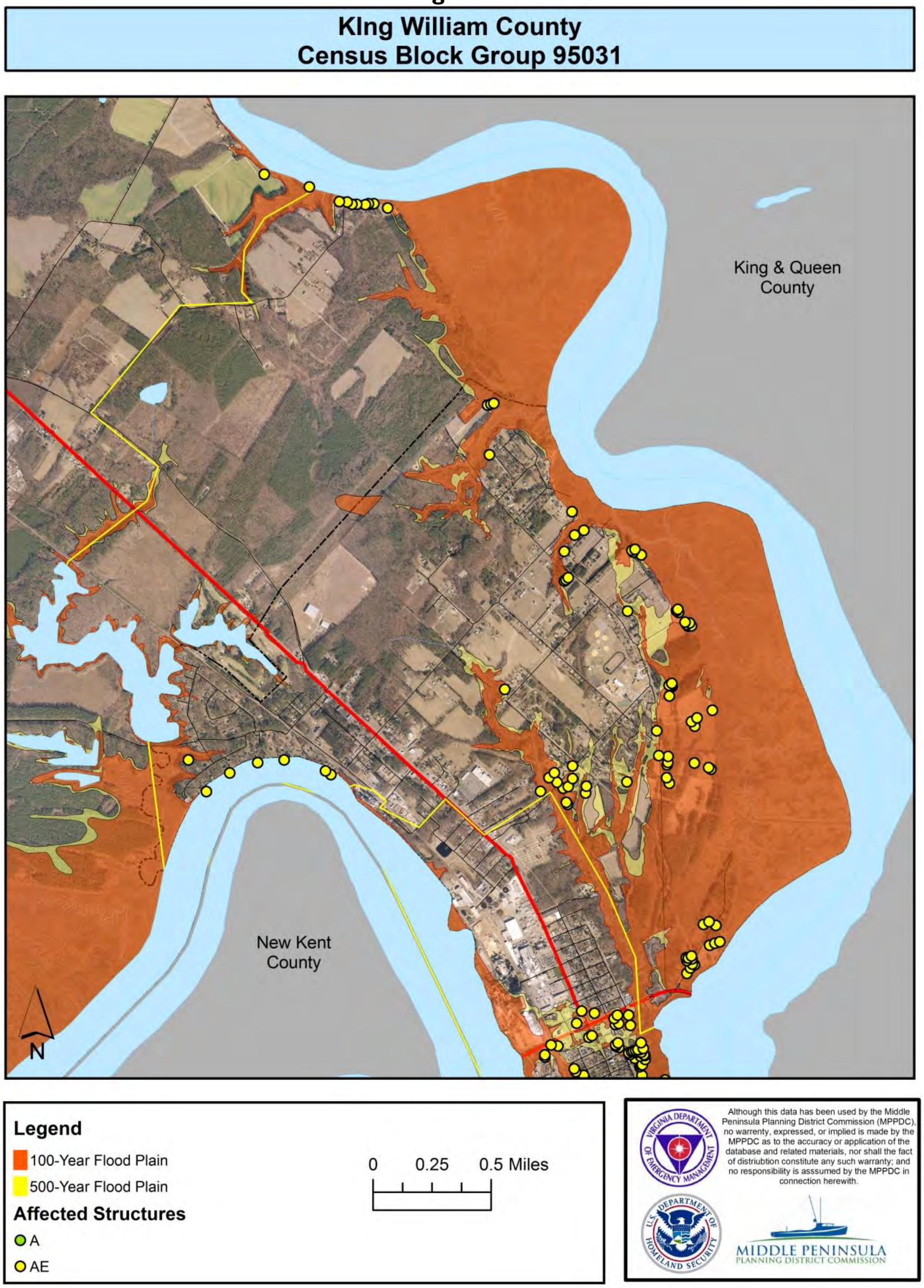
KIng William County
Census Block Group 95031
King & Queen County
New Kent County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
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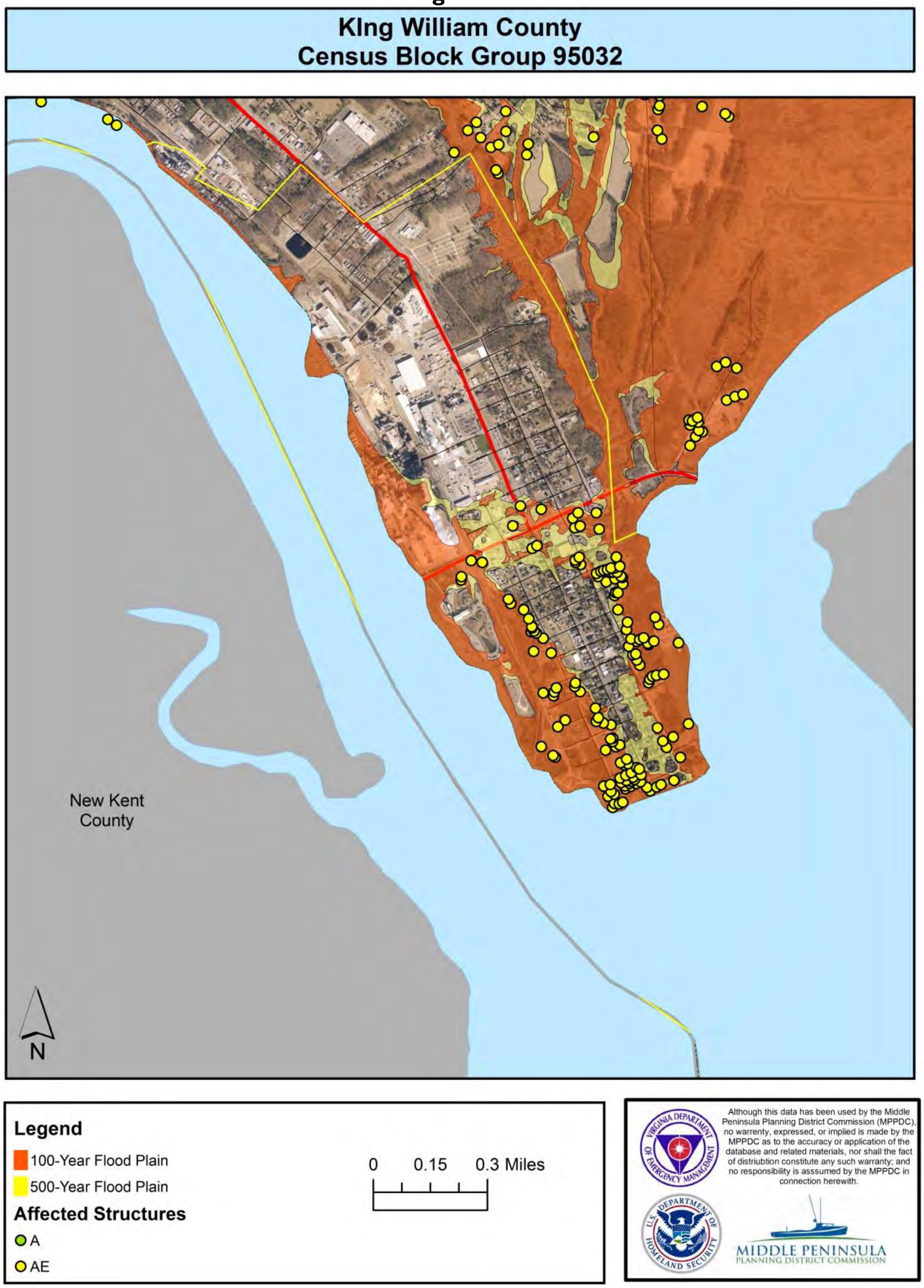
Figure 54:


KIng William County
Census Block Group 95032
New Kent
County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
A
AE
0 0.15 0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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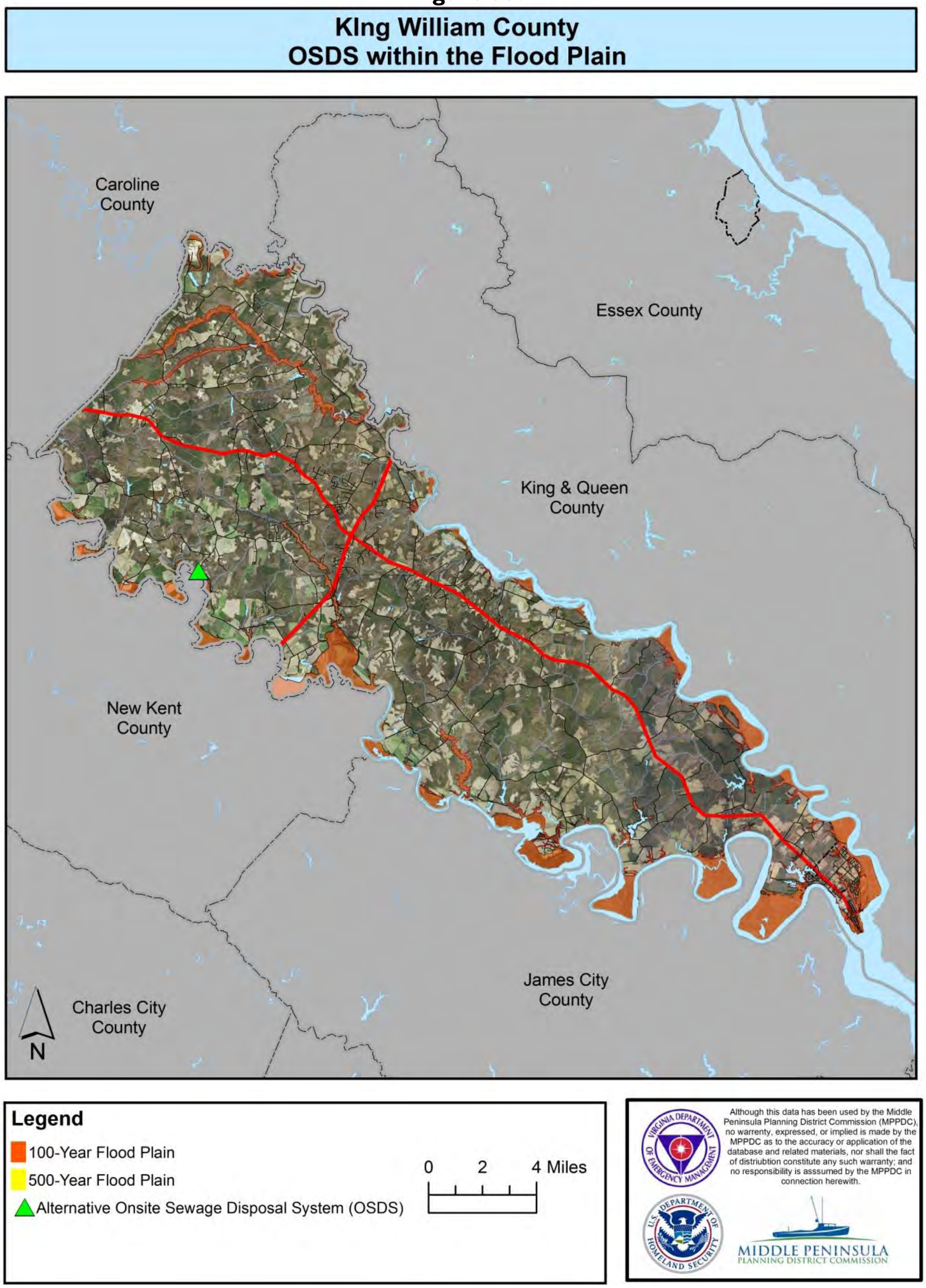
Alternative On-site Sewage Disposal Systems (OSDS)

The map below shows the locations of the installed OSDS facilities constructed in the 100-year floodplain in King William County.

Figure 55:



West Point Critical Facilities and Public Utilities
Located at the confluence of the Mattaponi and Pamunkey Rivers where they become the headwaters of the York River, there is public infrastructure, private residences and downtown businesses that are at risk of flooding during severe storms.

The town provides both public water and sewer service to its residents. The water system is owned and operated by the town and sustains little damage during flooding events.

The ownership and operation of the town's sewerage system has been turned over to the Hampton Roads Sanitation District (HRSD). The wastewater treatment plant is located at the east end of 23rd Street. The facility did not flood during Hurricane Isabel in 2003 and the vital electrical and mechanical controls are on a slightly elevated portion of the site and therefore, the facility's location does not pose a risk of flooding.

A sewer pump station located on 2nd Street near the point does have a flooding problem. During Hurricane Isabel, the pump motors in the well house flooded and needed to be dried out. However, the electrical controls are mounted high enough in the pump house so that they did not sustain flood damage. There is a sewer pump station located on 13th street that did not flood during Hurricane Isabel, but the floodwaters did reach within 1-foot of the facility.

Public Boat Landings
There is one public boat landing located along the Mattaponi River on the north side of the Lord Delaware Bridge on Glass Island Road. This facility does receive minor damage to the roadway and parking areas during severe storms.

Public Park Facility
On the south side of the Lord Delaware Bridge, there is a small town park with walking trails and benches adjacent to the water's edge. This is a new facility that was built in conjunction with the new bridge construction that was completed in 2006. Due to the minimal amount of infrastructure at this shoreline facility, it is an anticipated that there will be no more than minor damages from rising waters in this wetlands area adjacent to the Mattaponi River.

Repetitive and Severe Repetitive Loss Residential Structures in West Point
According to FEMA's records, there are 9 residential properties on the Repetitive Loss List and 0 on the Severe Repetitive Loss List as of 5/31/10.

The properties in the 100-year floodplain and 500-year floodplain are shown in the previous set of maps that also include King William County structures in the floodplain.

Numerous homes and downtown businesses at the southern end of West Point flood during severe storms particularly as flood waters reached 8 feet 6 inches above mean low water which is 6 inches above the 8 ft 100-year flood plan elevation. Additionally winds were sustained at excess of 80 miles per hour. Of the homes that underwent repairs, 2 of them were elevated by the homeowners at their own expense.

The West Point School Complex, which serves as the town's shelter, is located on the northern side of the town and the buildings are not subjected to floodwaters. However, Chelsea Road is located along the Mattaponi River and it is 1 of 2 routes that are used to access the school complex. This roadway does flood during severe storms.

4.5.4. Gloucester Critical Facilities and Public Utilities

The county has a relatively extensive network of public water and sewer facilities in and around the Gloucester Courthouse area. The Beaverdam Reservoir, located just north of the courthouse area, serves as the drinking water source for the county's public water supply system. As discussed earlier in the Dam Impoundment Section of the plan, the dam is structurally well-built and remains fully certified by the Virginia Department of Conservation and Recreation (Figure 3). Below the dam there are approximately 200 homes that would flood if the Reservoir structure failed. However, in 1999 the impoundment overflowed during Hurricane Floyd yet no flood damage to the home since the excess water flowed downstream using the emergency spillway.

Table 15 provides a list of dams within the locality that may be impacted by natural hazards as well.

Table 15: Dams in Gloucester County (Virginia Department of Conservation and Recreation, 2013)

Dam Name	Hazard Ranking	Top Height	Water Body
Woodberry Farm	Low Hazard	8	Jones Creek
Weaver Dam	Low Hazard	6	Jones Creek
Haynes	Low Hazard	15	Carter Creek
Robins Creek	Significant Hazard	16	Wilson Creek
Cow Creek	Significant Hazard	16	Cow Creek
Burke	Significant Hazard	21	Burke Mill Stream
Cypress Shores River	Low Hazard	15	Trib. Piankatank River
Haines Pond	Low Hazard	9	Carvers Creek
Beaverdam Reservoir	High Hazard	39	Beaverdam Creek
Wood Duck Pond	Low Hazard	12.7	Fox Mill Run
Leigh Lake	Low Hazard, Special	12	James Creek

The water distribution system does not suffer damage during severe storm events since it is a closed underground system. The sewerage collection lines and pumps stations are owned and operated by Gloucester County. There are 2 pump stations in the Gloucester Courthouse area (Pump # 11 and Pump #13) that sustained damage during Hurricane Floyd in 1999. The damage was caused by floodwaters resulting from the overtopping of the Beaverdam Reservoir as previously mentioned. After the wastewater is collected, it is transported in a large force main that runs down Route 17, crosses under the York River and then flows into the York River Wastewater Treatment Plant in York County. The large force main and treatment plant are owned and operated by the Hampton Roads Sanitation District. The force main is a closed underground system that does not sustain damage during severe flooding events.

The Achilles Elementary School site, located in the southeastern section of the county, is adversely affected by flood waters from storms surges associated with a Category 1 hurricane.

According to VDOT officials, flood prone roads in Gloucester County include the following:

Table 16. Gloucester County Flood Prone Roads

Route	Road Name	Location of Floodwaters
684	Starvation Road	From Big Oak Lane to ESM
662	Allmondsville Road	From Rte. 606 to Rte. 618
618	Chappahosic Road	From Rte. 662 to Rte. 639
636	Brays Point Road	From Eagle Lane to ESM
1303	Carmines Islands Road	From Gardner Lane to ESM
646	Jenkins Neck Road	Various spots from Owens Road to ESM
648	Maundys Creek Road	From Rte. 649 to ESM
649	Maryus Road	From Haywood Seafood Lane to ESM
652	Rowes Point Road	From 653 to ESM
649	Severn Wharf Road	Various spots from 653 to ESM

Public Boat Landings

There are **12** public boat landings in Gloucester County, including:

- *Cappahosic Landing*: At the end of Cappahosic Road, York River Access provides fishing, beach, picnicking, limited parking and restrooms. May thru October Park area maintained by Gloucester County Landing maintained by VDOT

- Cedar Bush, Oliver's Landing Location: End of Cedar Bush Road York River Access Parking Bank fishing Maintained by VDOT

- Cherry Point Landing - car top boats only, no trailer access Location: End of Broad Marsh Rd Severn River Access Maintained by VDOT

- Deep Point Landing Location: End of Deep Point Lane Piankatank River Access Bank fishing Picnicking Parking Maintained by Game and Inland Fisheries **(Temporarily closed)**

- Field's Landing - car top boats only, no trailer access Location: End of Field's Landing Road York River Access Maintained by VDOT

- Glass Point Landing - car top boats only, no trailer access Location: End of Glass Road Severn River Access Maintained by Gloucester County

- Gloucester Point Beach Park Location: End of Greate Road, next to Coleman Bridge York River Access Sandy beach Swimming Picnicking Outdoor Showers - seasonal Restrooms Playground Fishing Pier Parking 2 Landings Park maintained by Gloucester County

- John's Point Landing - car top boats only, no trailer access Location: End of John's Point Road Fishing Parking Maintained by VDOT

- Miller's Landing - car top boats only, no trailer access Location: End of Miller's Landing Road Poropotank River Access Fishing Parking Maintained by VDOT

- Payne's Landing - car top boats only, no trailer access Location: End of Paynes Landing Road Ware River Access Maintained by Gloucester County

- Severn Landing - car top boats only, no trailer access Location: End of Severn Wharf Road Mobjack Bay Access Maintained by VDOT

- Tanyard Landing Location: End of Tanyard Landing Road Poropotank River Access - west to the York River Parking Maintained by Game and Inland Fisheries

Repetitive and Severe Repetitive Loss Residential Structures in Gloucester County
According to FEMA's records, there are 103 residential properties on the Repetitive Loss List and 1 on the Severe Repetitive Loss List as of 5/31/10.

Properties In 100-year Floodplain by Census Block Group
The following series of maps show the location of structures in Gloucester County that are in Flood Zone A, Flood Zone AE or Flood Zone VE. This 2004 information is the latest structure data available. The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 56:

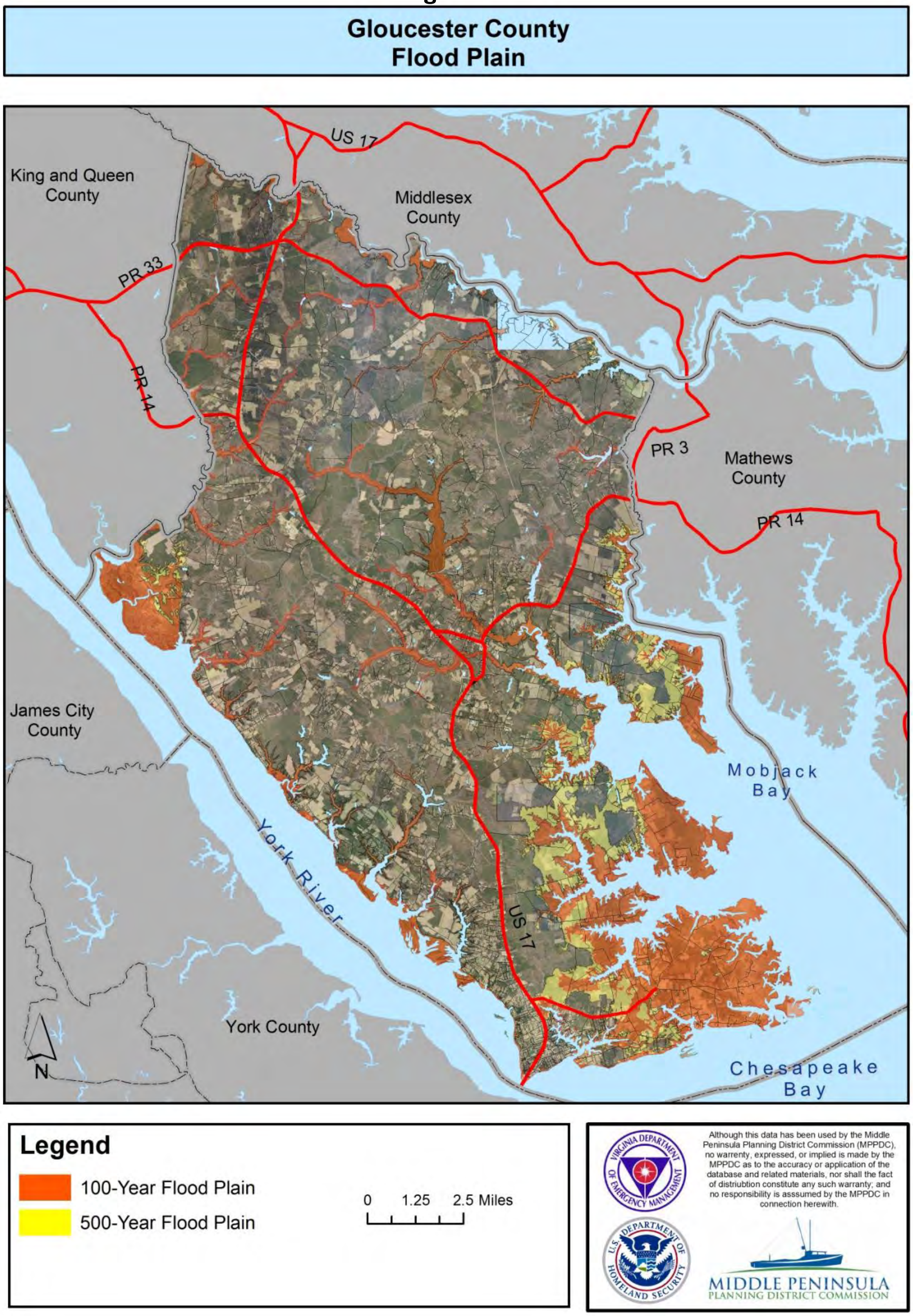

Gloucester County
Flood Plain
King and Queen County
Middlesex County
US 17
PR 33
PR 14
PR 3
Mathews County
PR 14
James City County
Mobjack Bay
York River
US 17
York County
Chesapeake Bay
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 1.25 2.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 57:

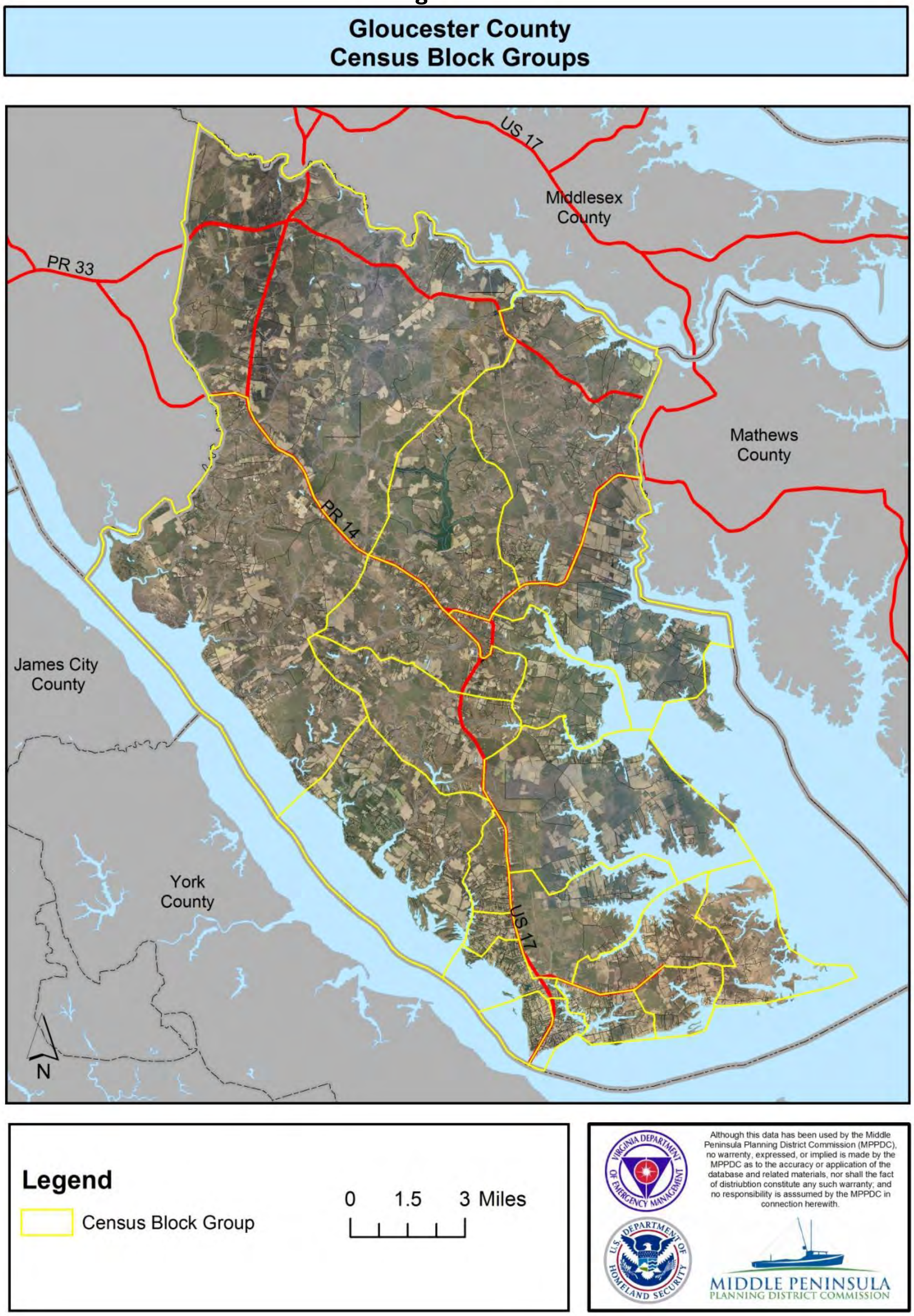

Gloucester County
Census Block Groups
US 17
Middlesex County
PR 33
Mathews County
PR 14
James City County
York County
US 17
N
Legend
Census Block Group
0 1.5 3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 58:

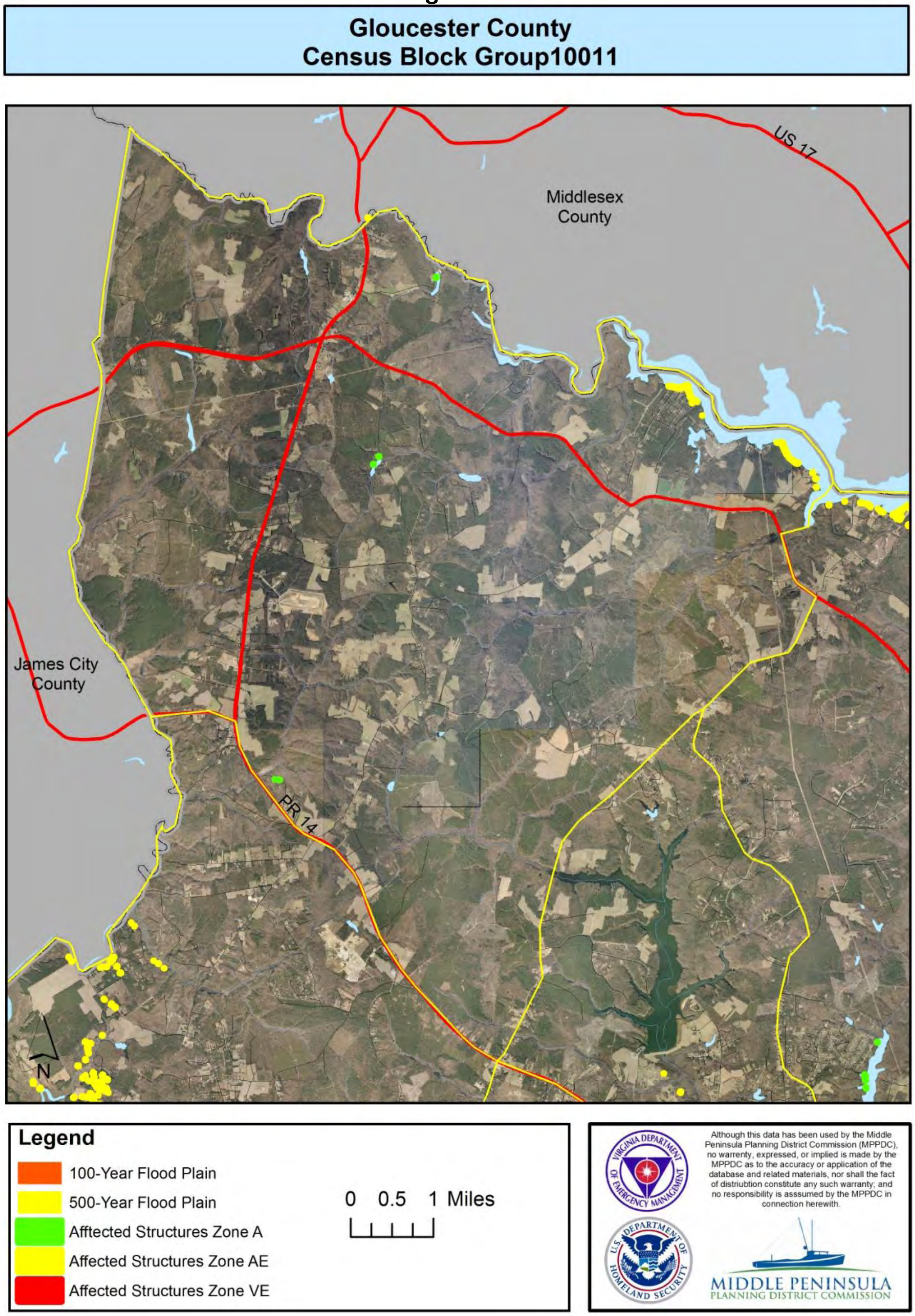
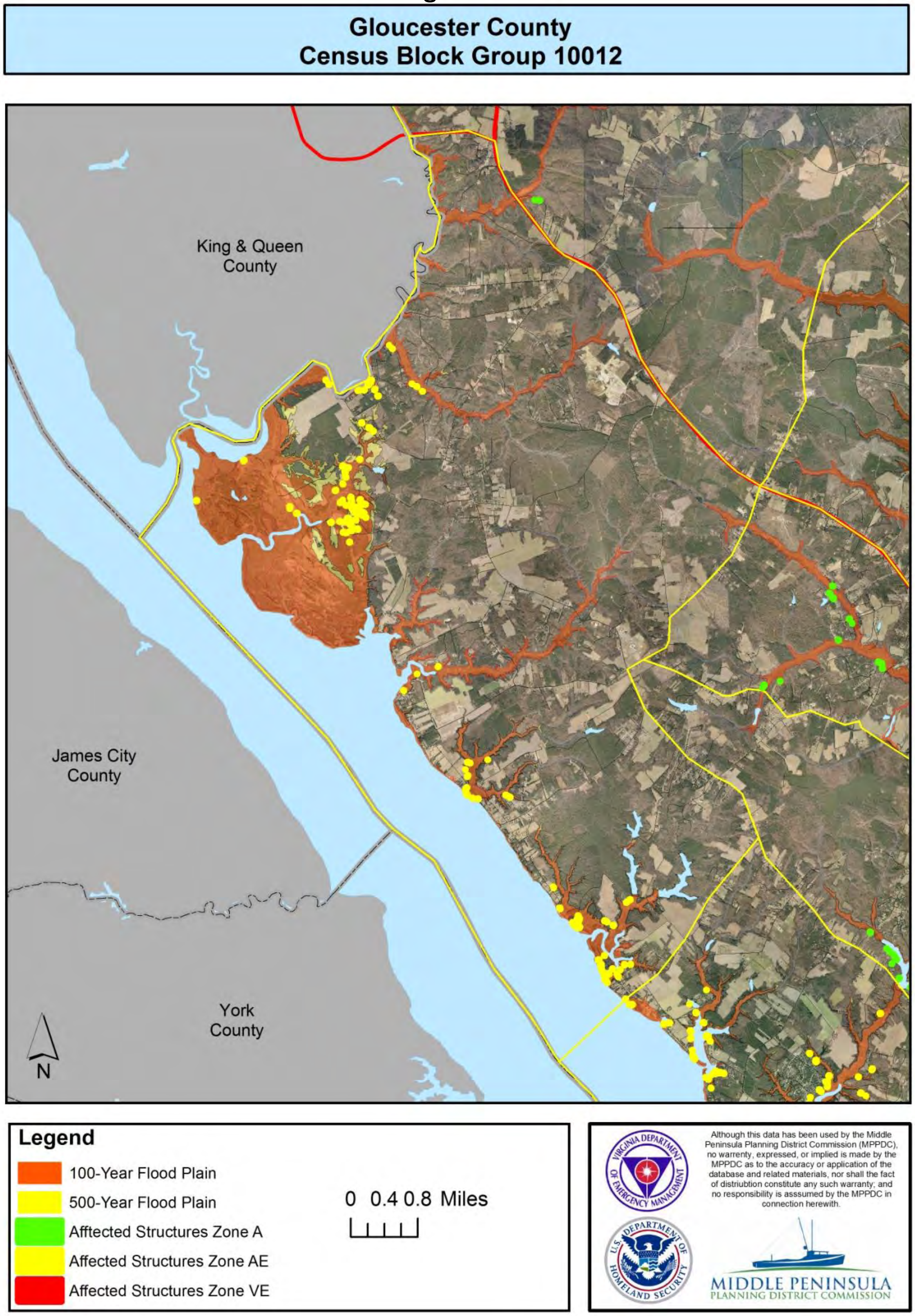

Gloucester County
Census Block Group10011
US 17
Middlesex County
James City County
PR 14
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Afftected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA PLANNING DISTRICT COMMISSION

Figure 59:


Gloucester County
Census Block Group 10012
King & Queen County
James City County
York County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Afftected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.4 0.8 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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PLANNING DISTRICT COMMISSION

Figure 60:

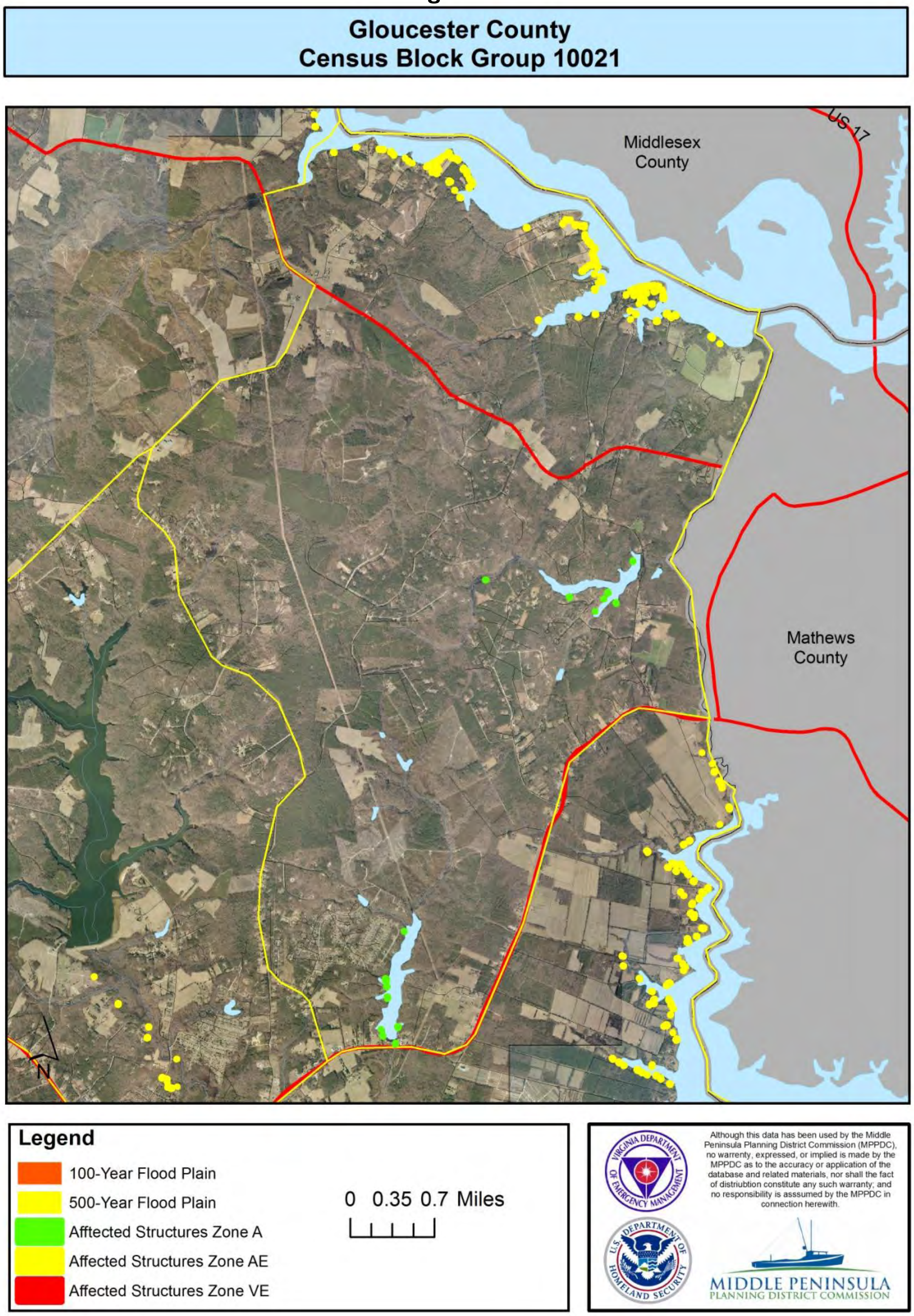
Gloucester County
Census Block Group 10021
Middlesex County
US 17
Mathews County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Afftected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.35 0.7 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 61:

Gloucester County
Block Group 10023

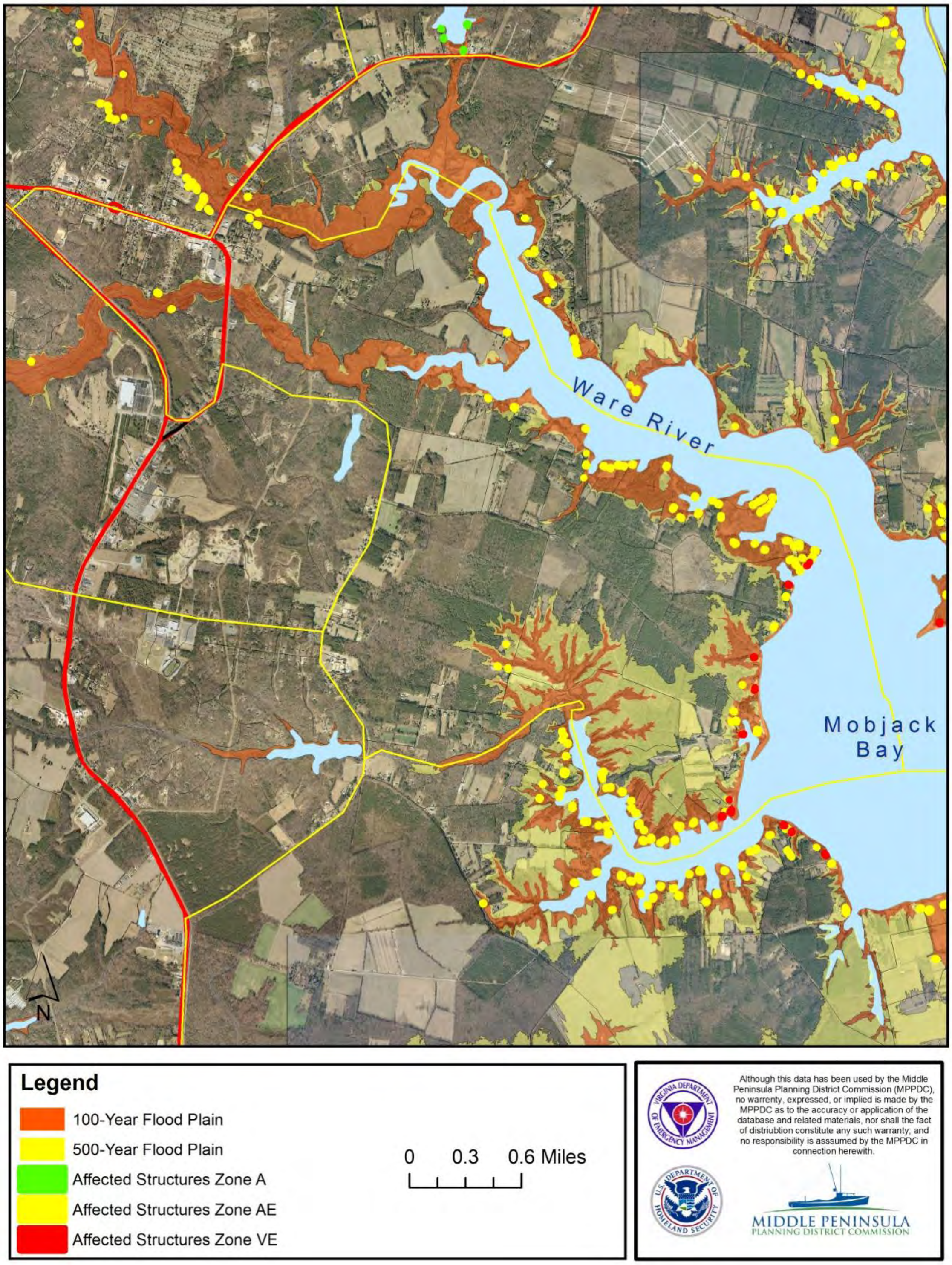


Figure 62:

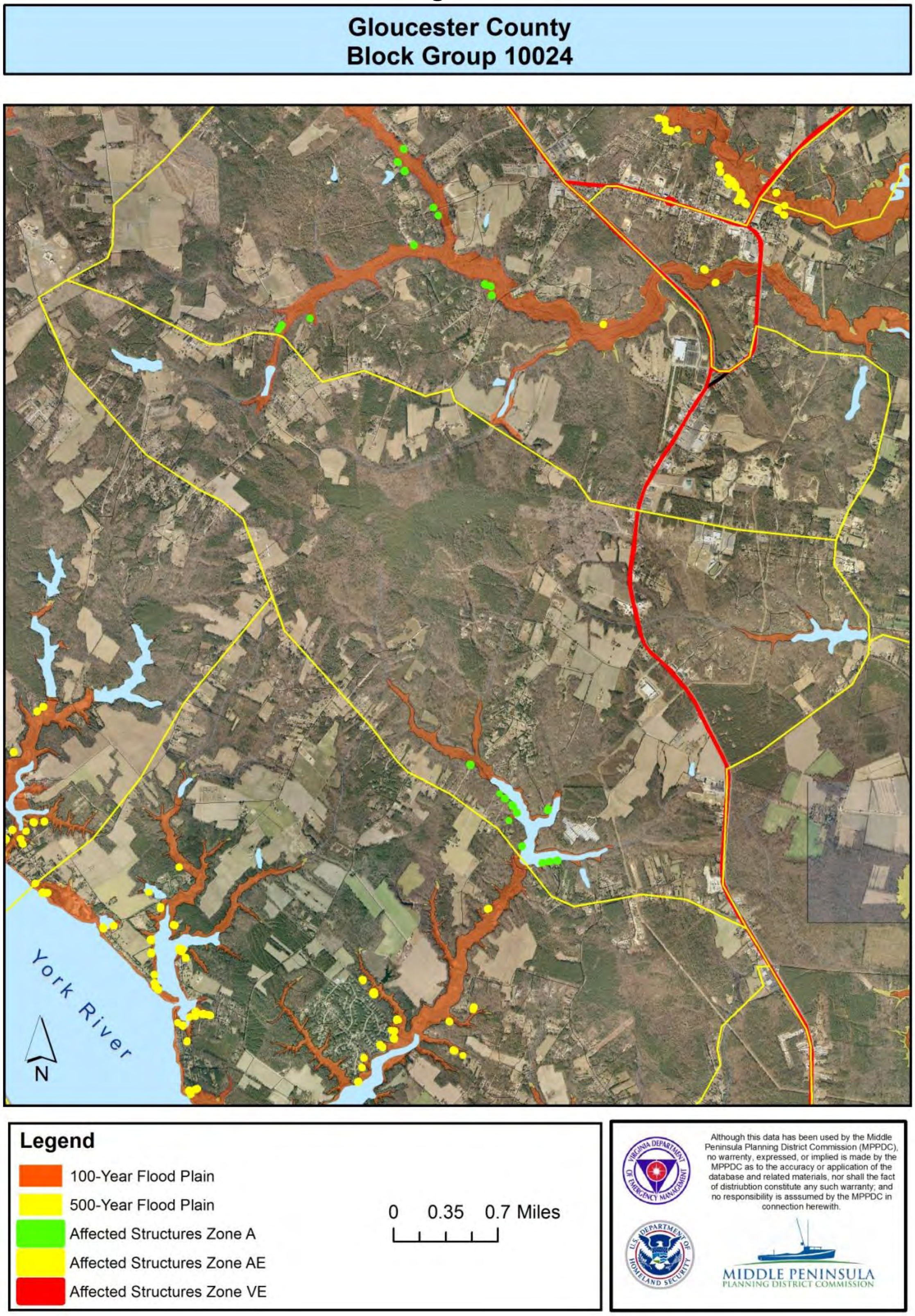
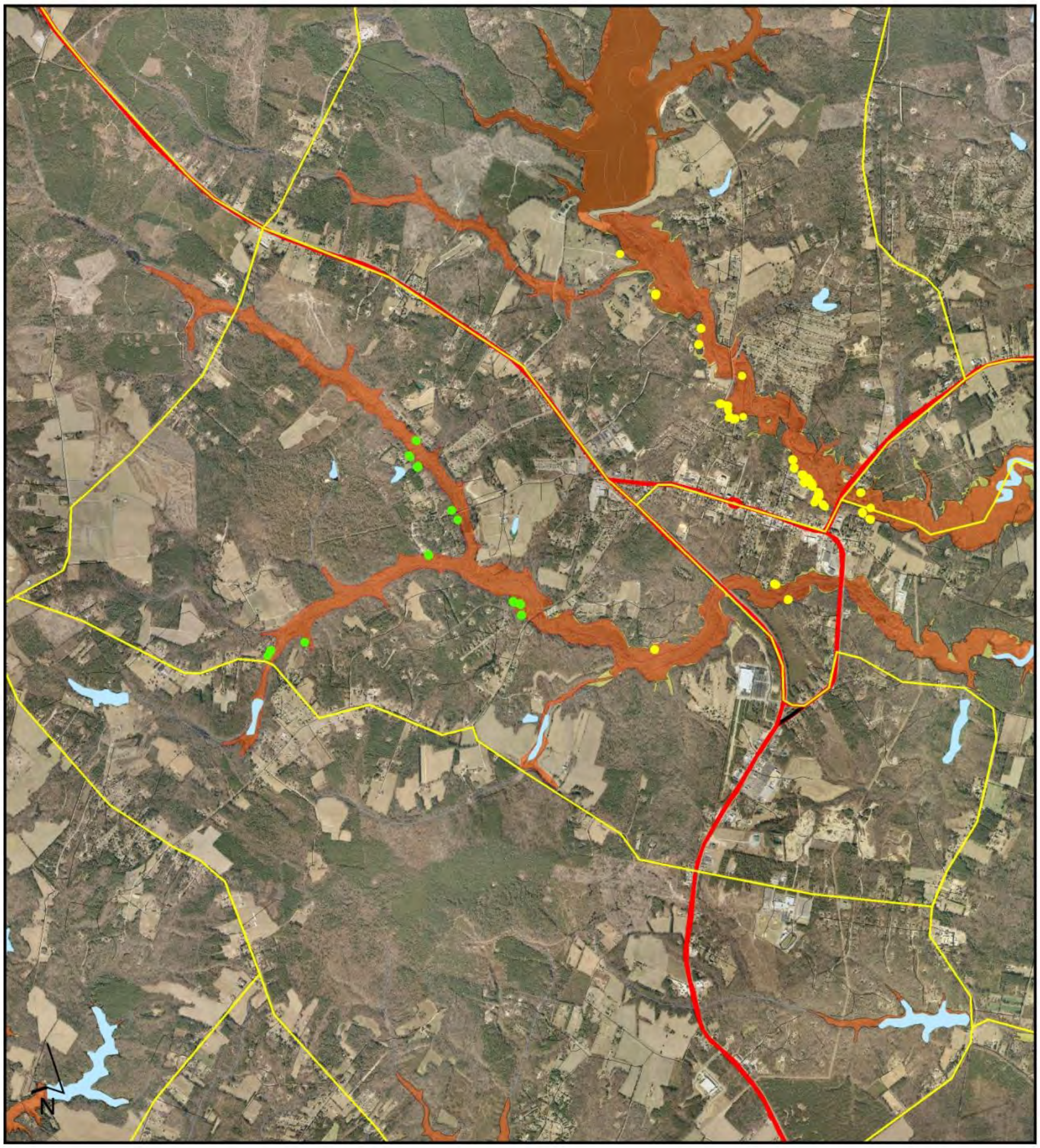

Gloucester County
Block Group 10024
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.35 0.7 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 63:

Gloucester County
Block Group 10025



Legend

- 100-Year Flood Plain
- 500-Year Flood Plain
- Affected Structures Zone A
- Affected Structures Zone AE
- Affected Structures Zone VE

0 0.375 0.75 Miles

Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.

MIDDLE PENINSULA PLANNING DISTRICT COMMISSION

Figure 64:

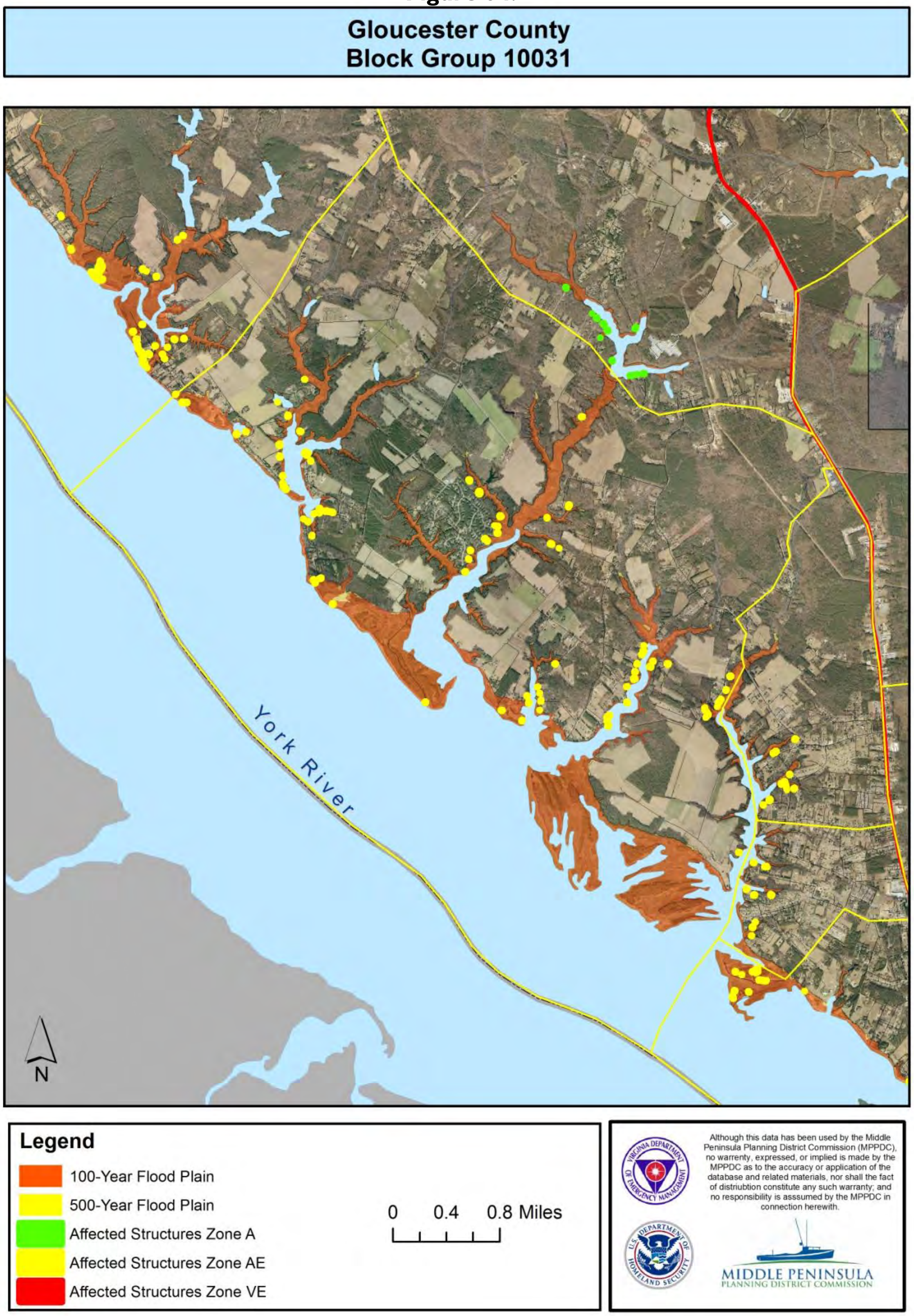

Gloucester County
Block Group 10031
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.4 0.8 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 65:

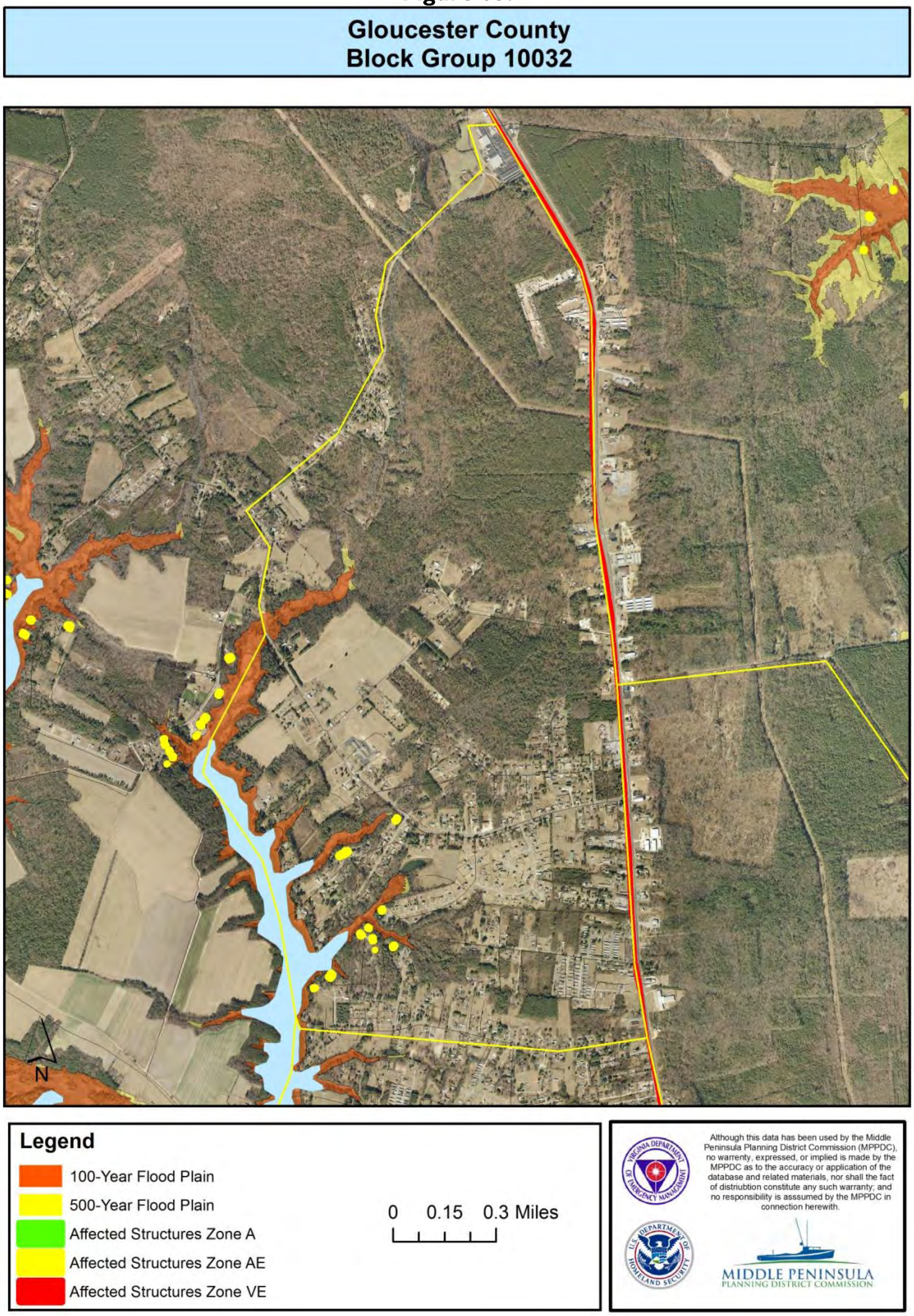

Gloucester County
Block Group 10032
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.15 0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 66:

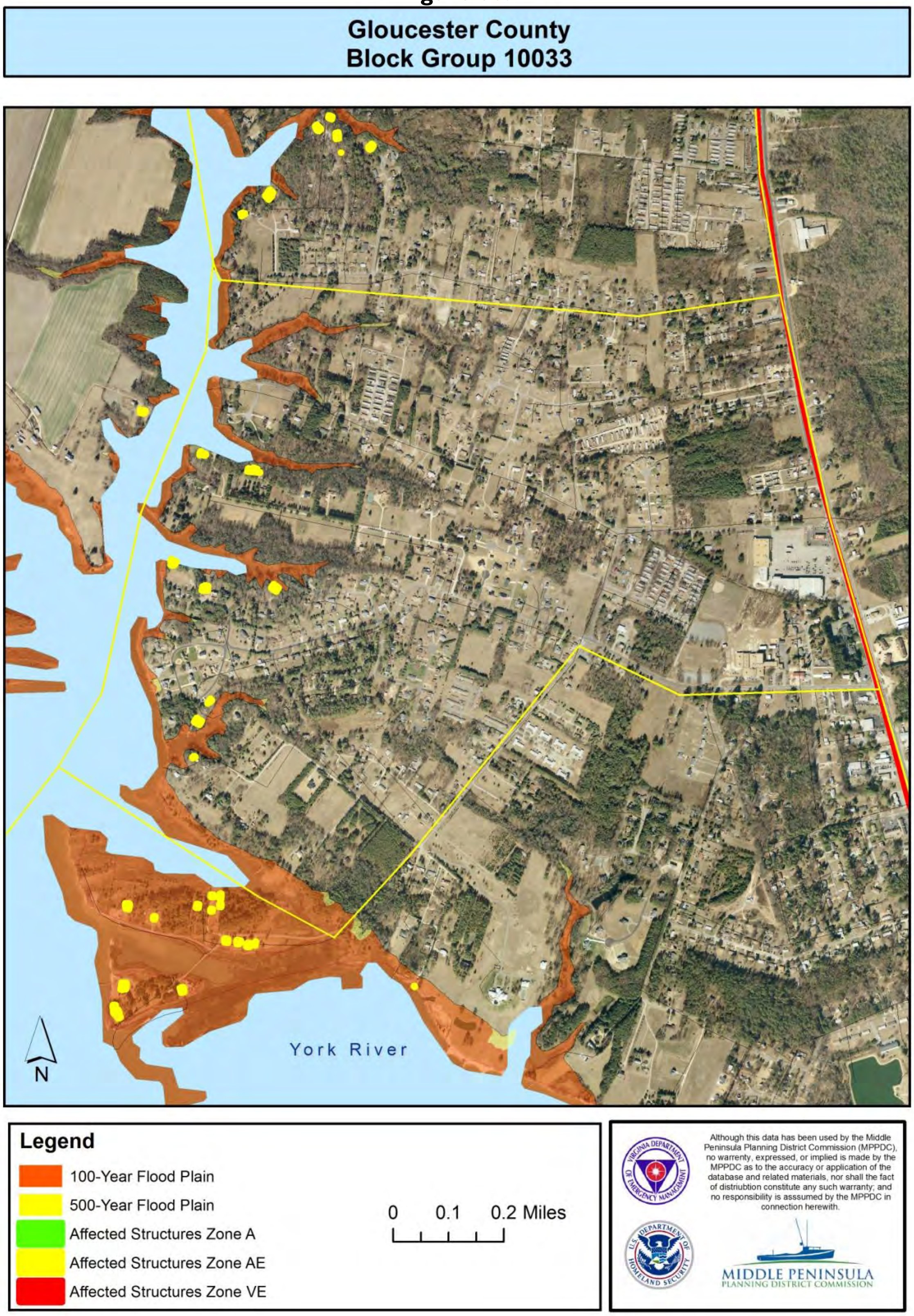
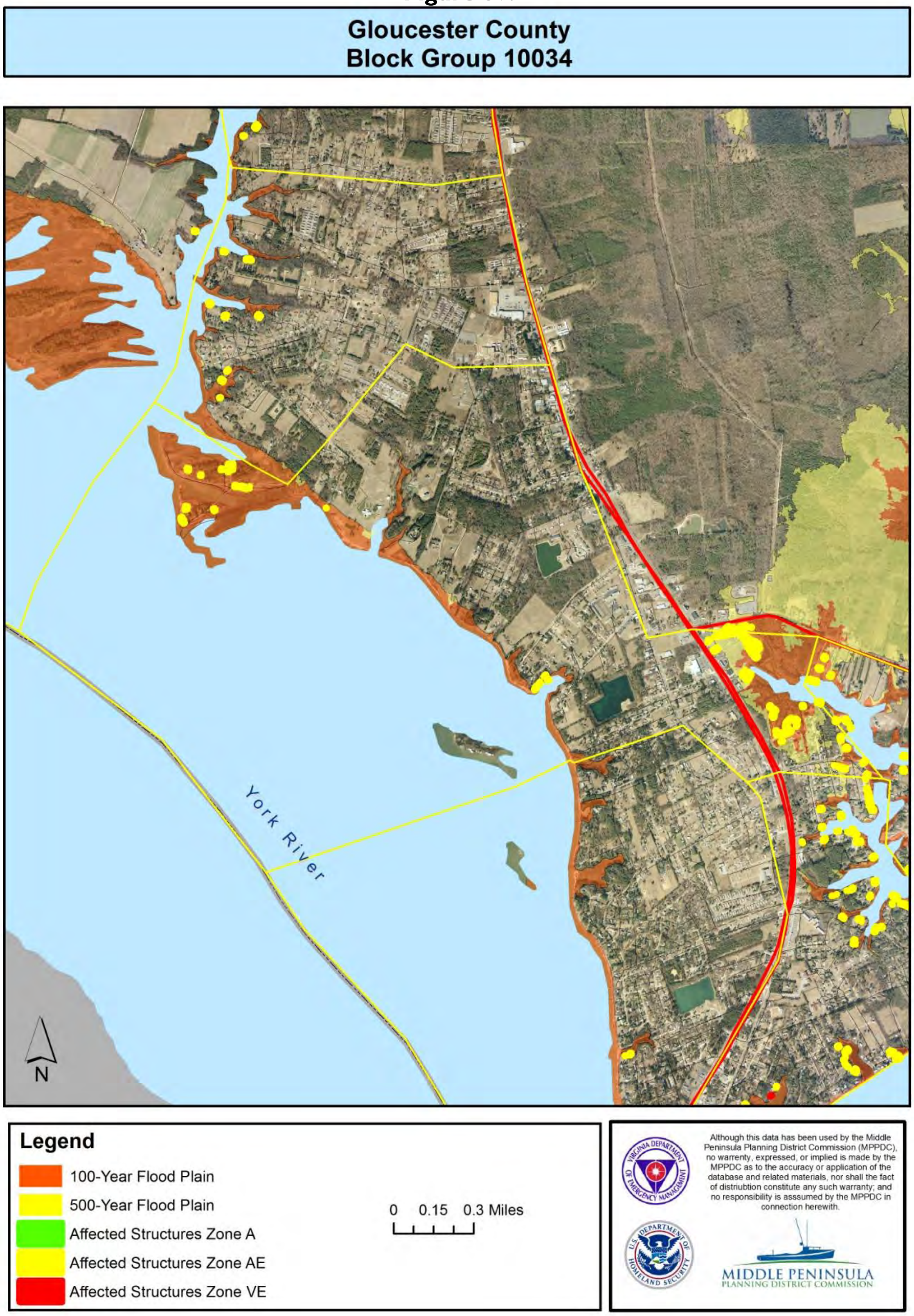

Gloucester County
Block Group 10033
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.1 0.2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 67:



Gloucester County
Block Group 10034
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.15 0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 68:

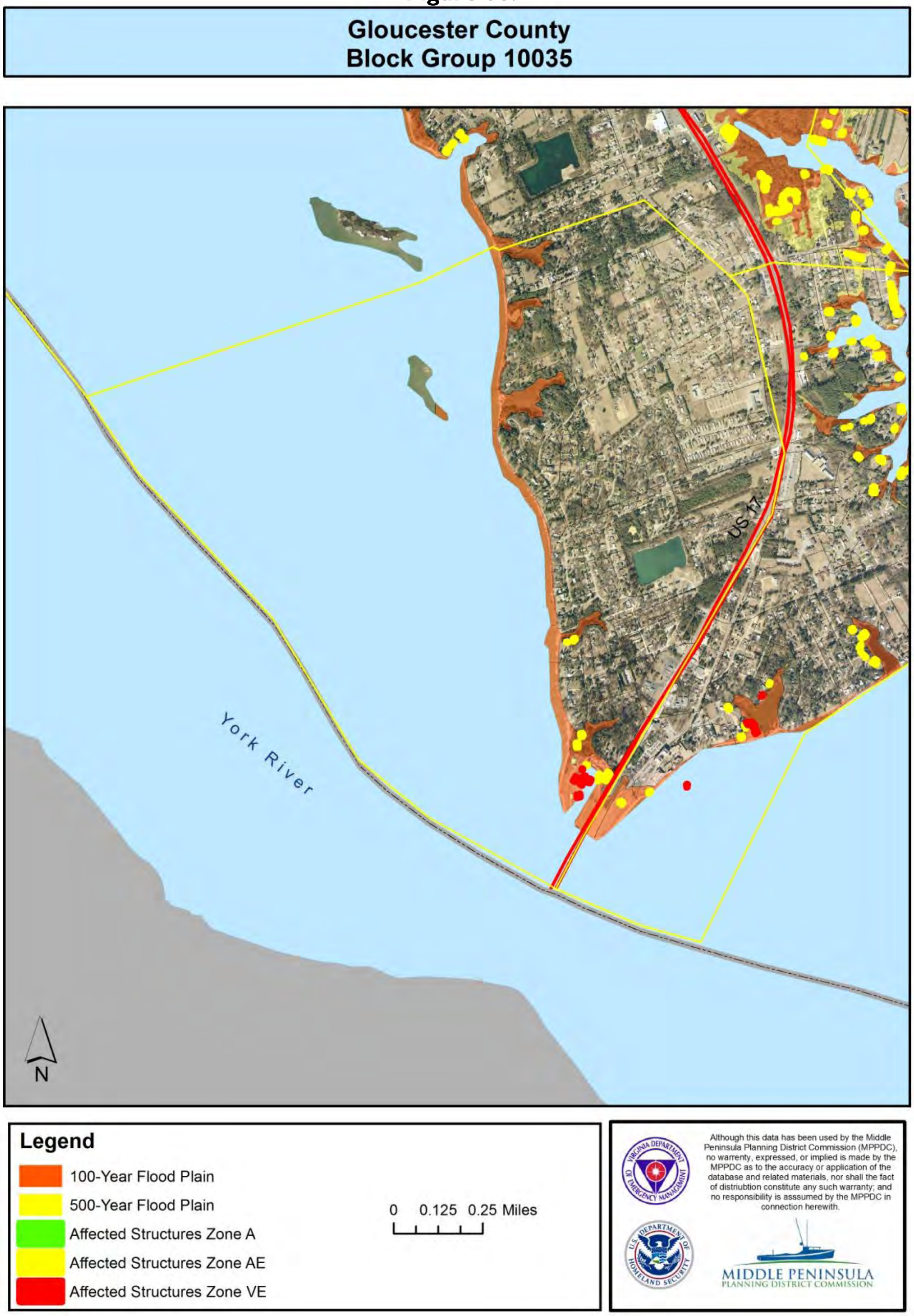

Gloucester County
Block Group 10035
US 17
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.125 0.25 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
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Figure 69:

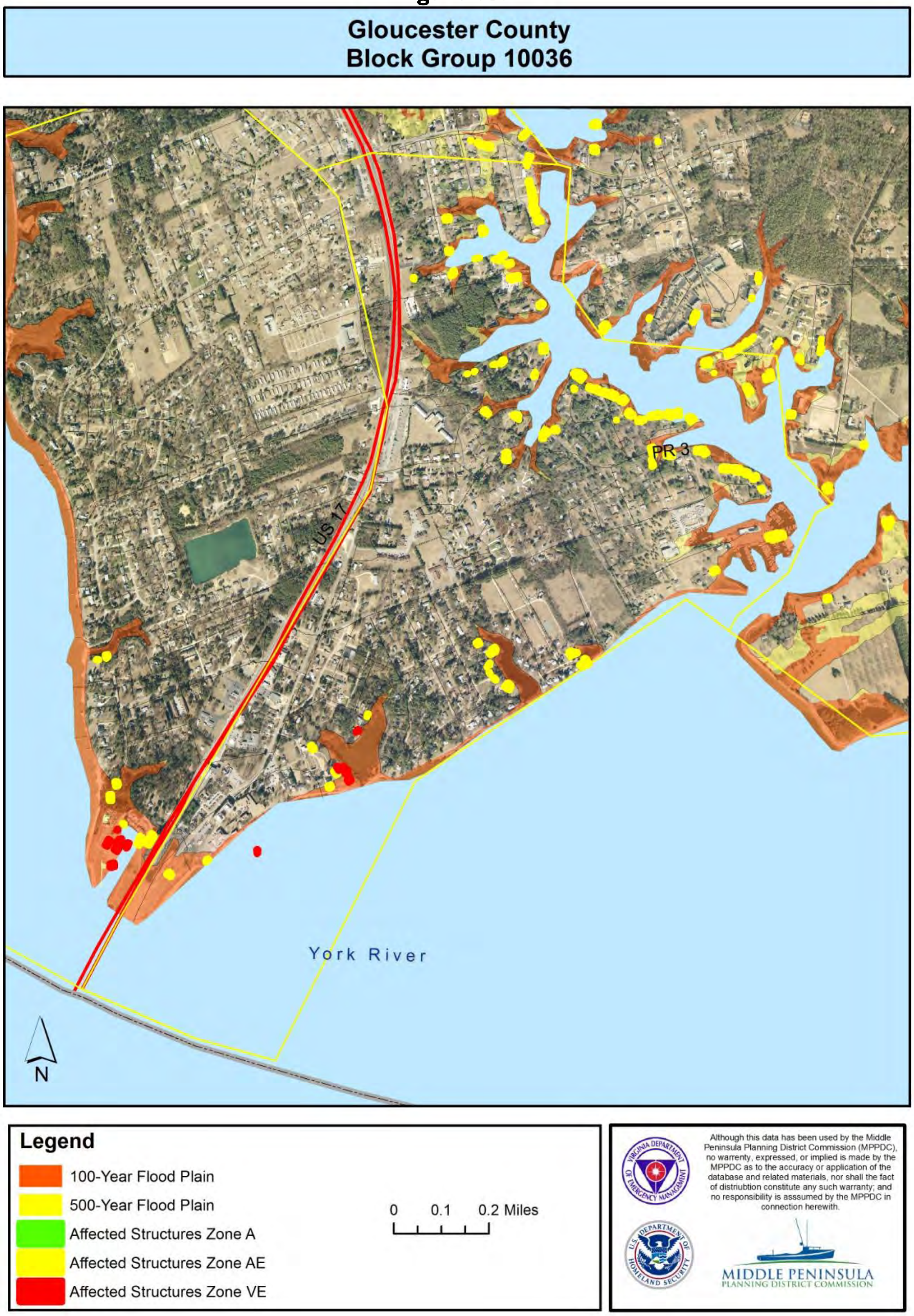
Gloucester County
Block Group 10036
US 17
PR 3
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.1 0.2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 70:

Gloucester County Block Group 10041

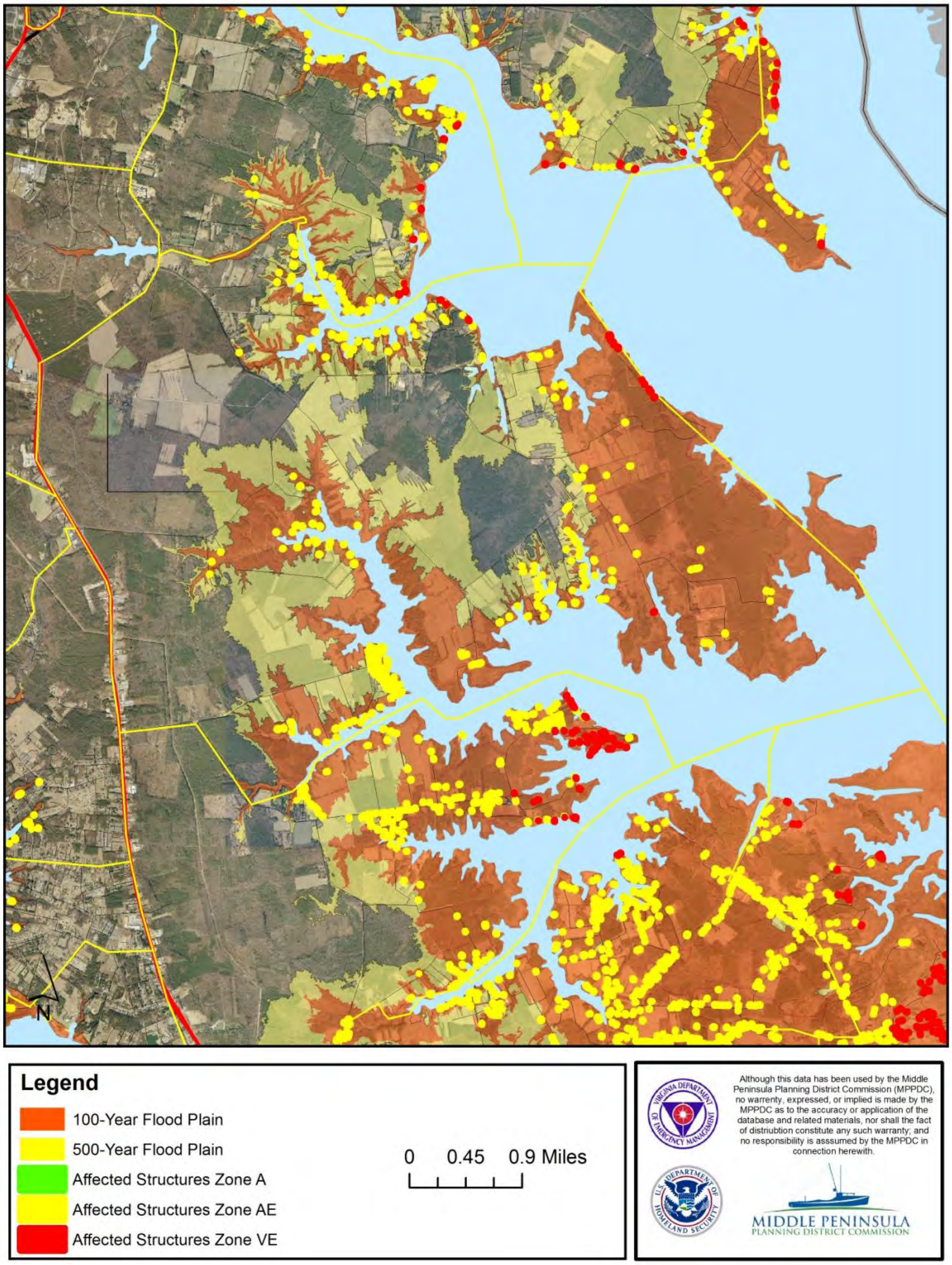

Figure 71:

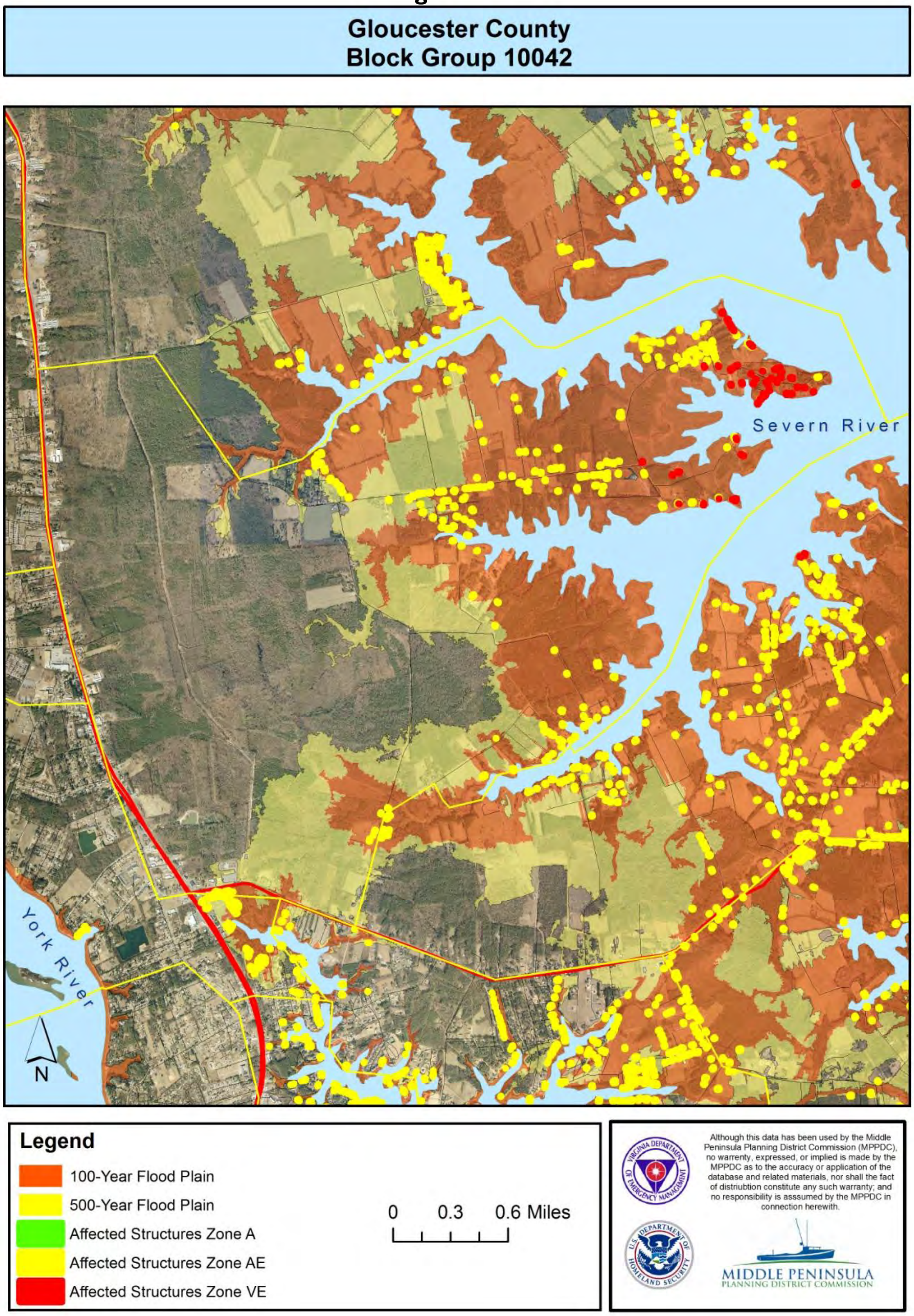
Gloucester County
Block Group 10042
Severn River
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.3 0.6 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 72:

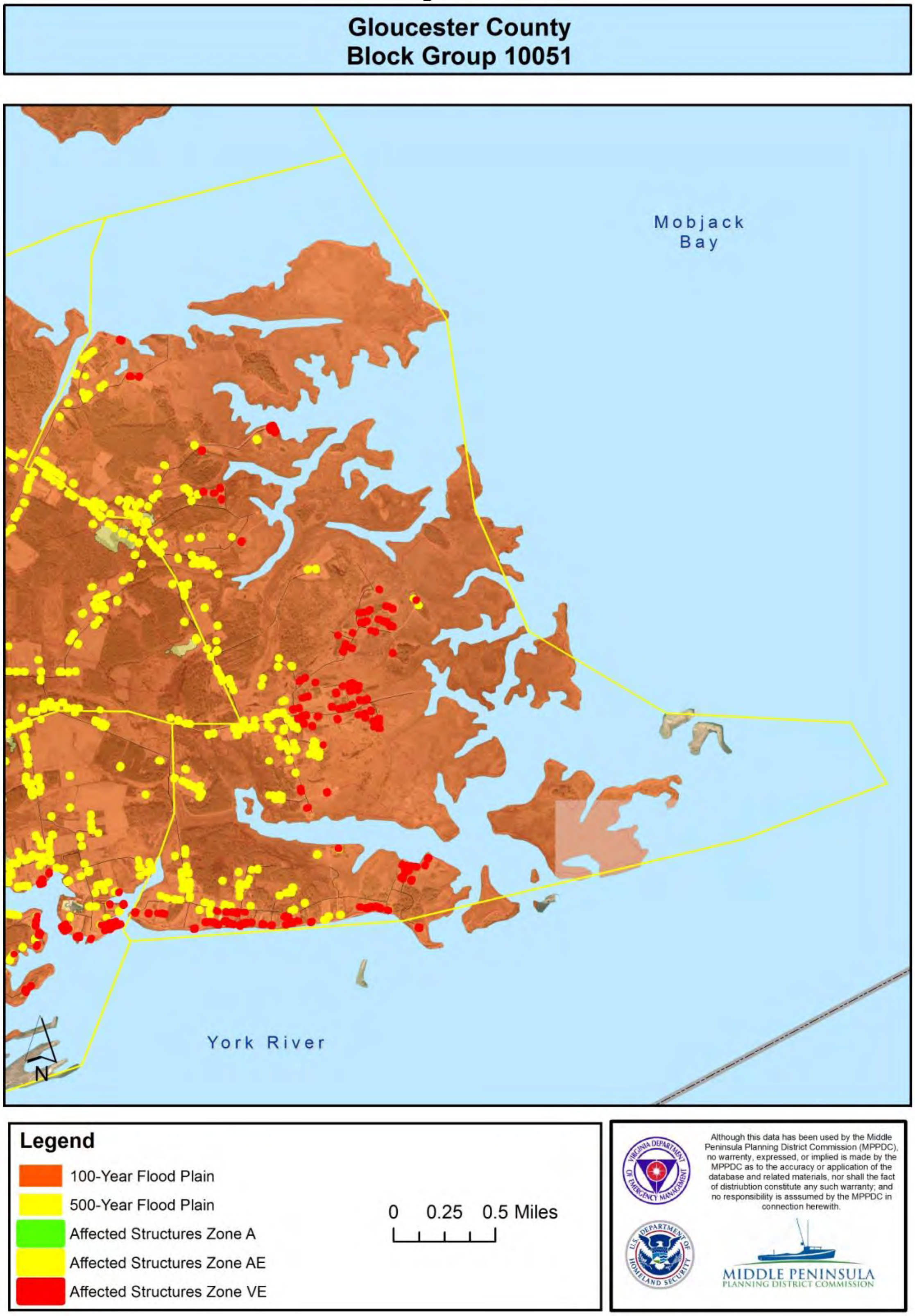

Gloucester County
Block Group 10051
Mobjack
Bay
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 73:

Gloucester County
Block Group 10052

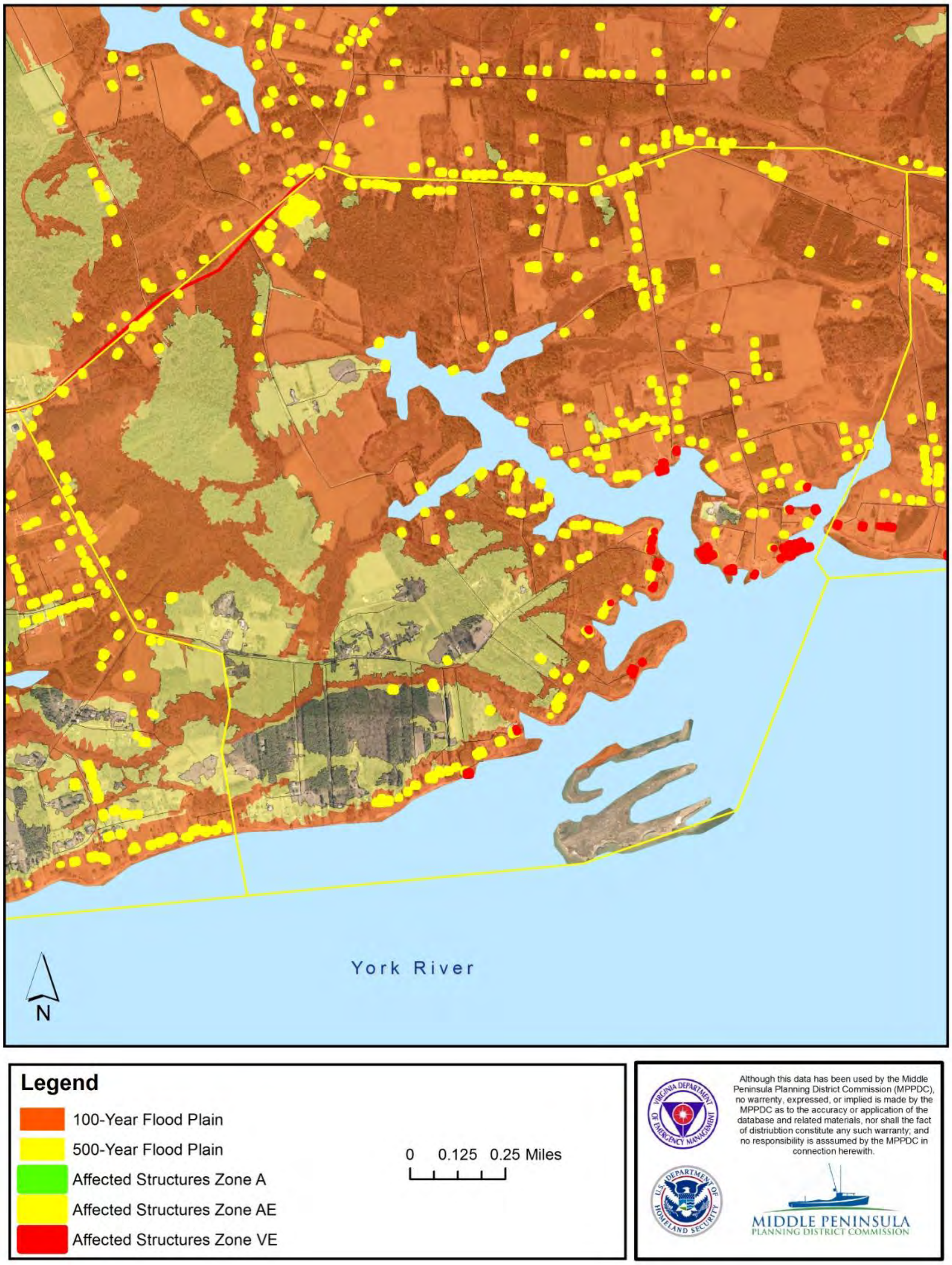
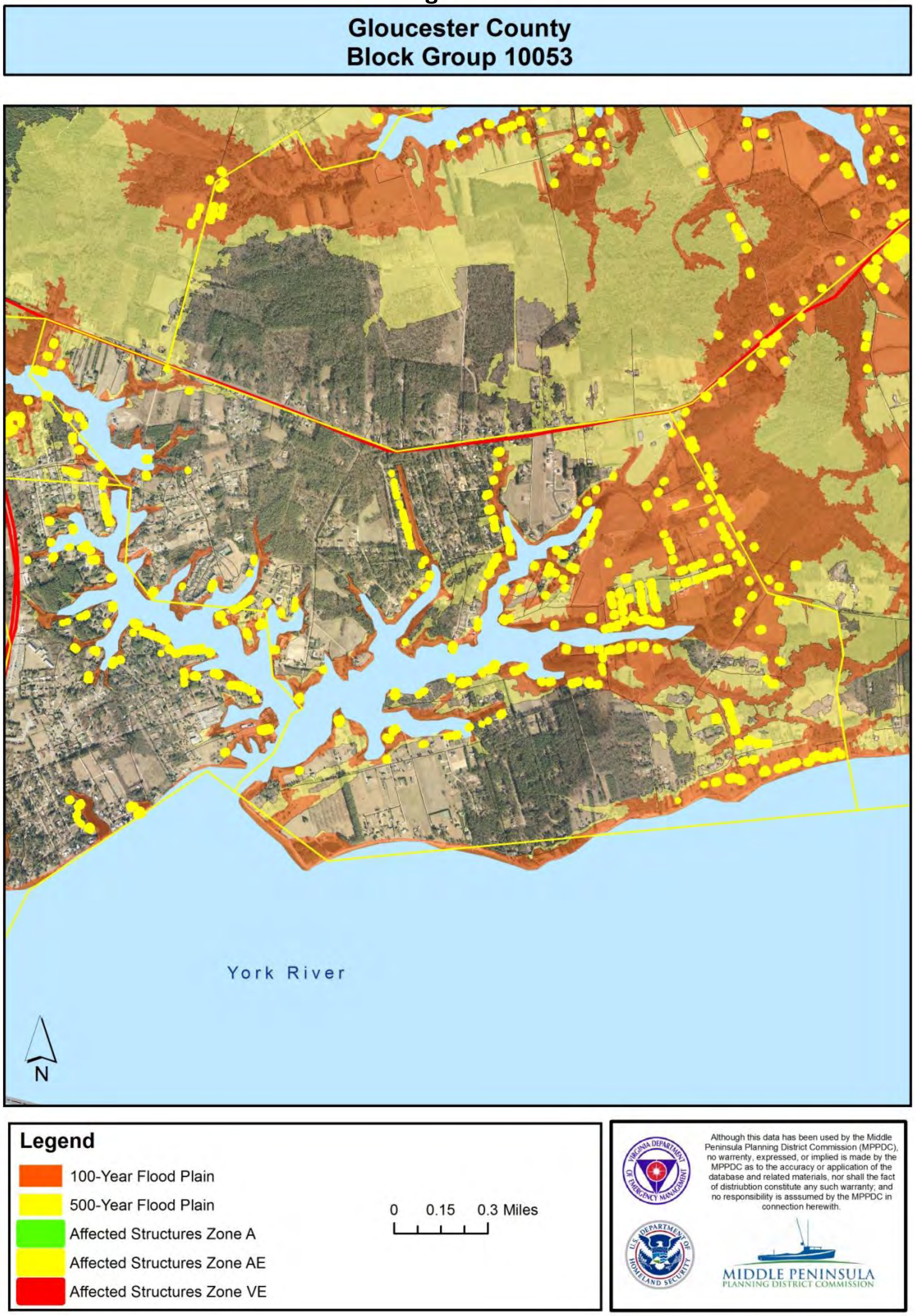


Figure 74:


Gloucester County
Block Group 10053
York River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.15 0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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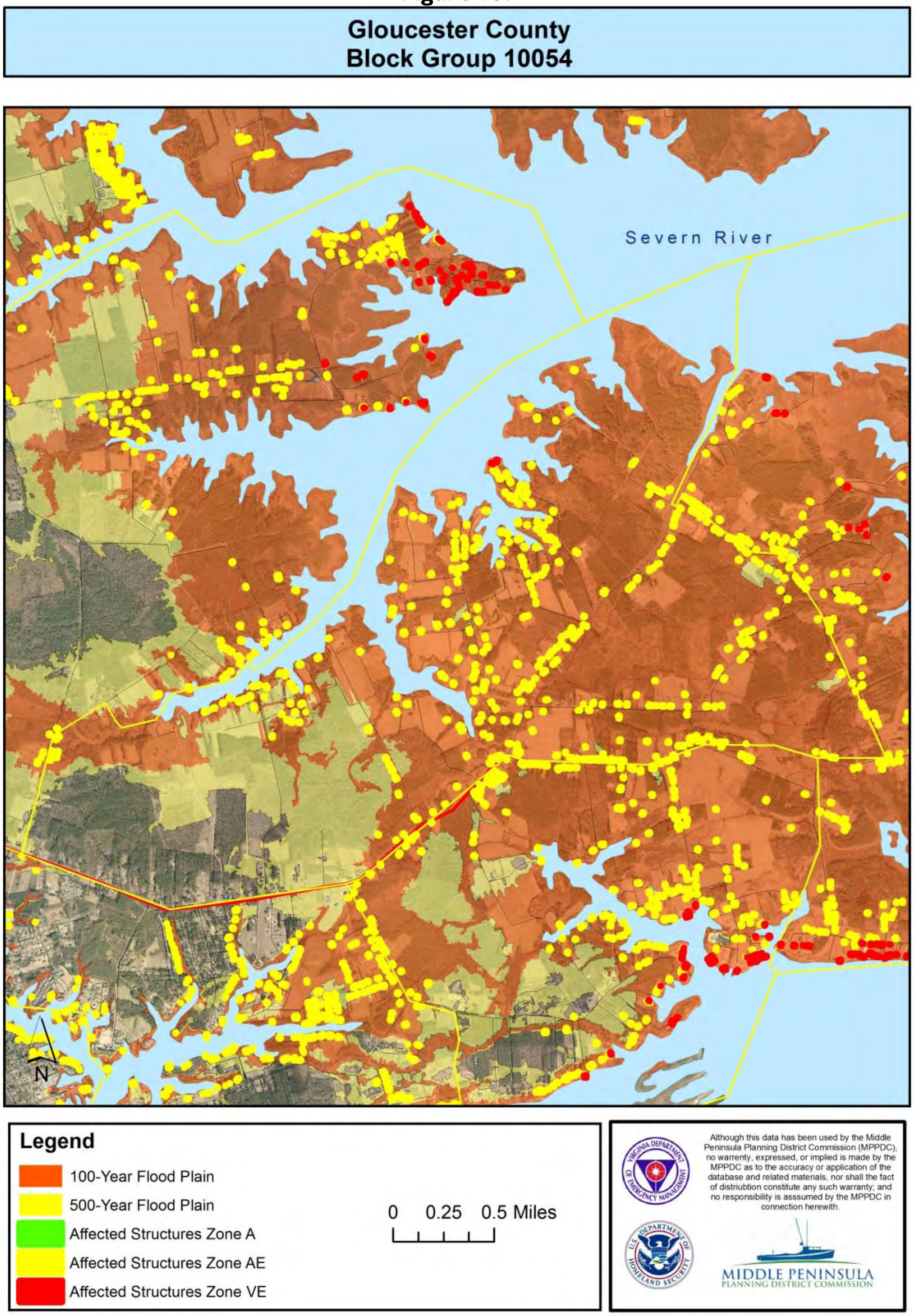
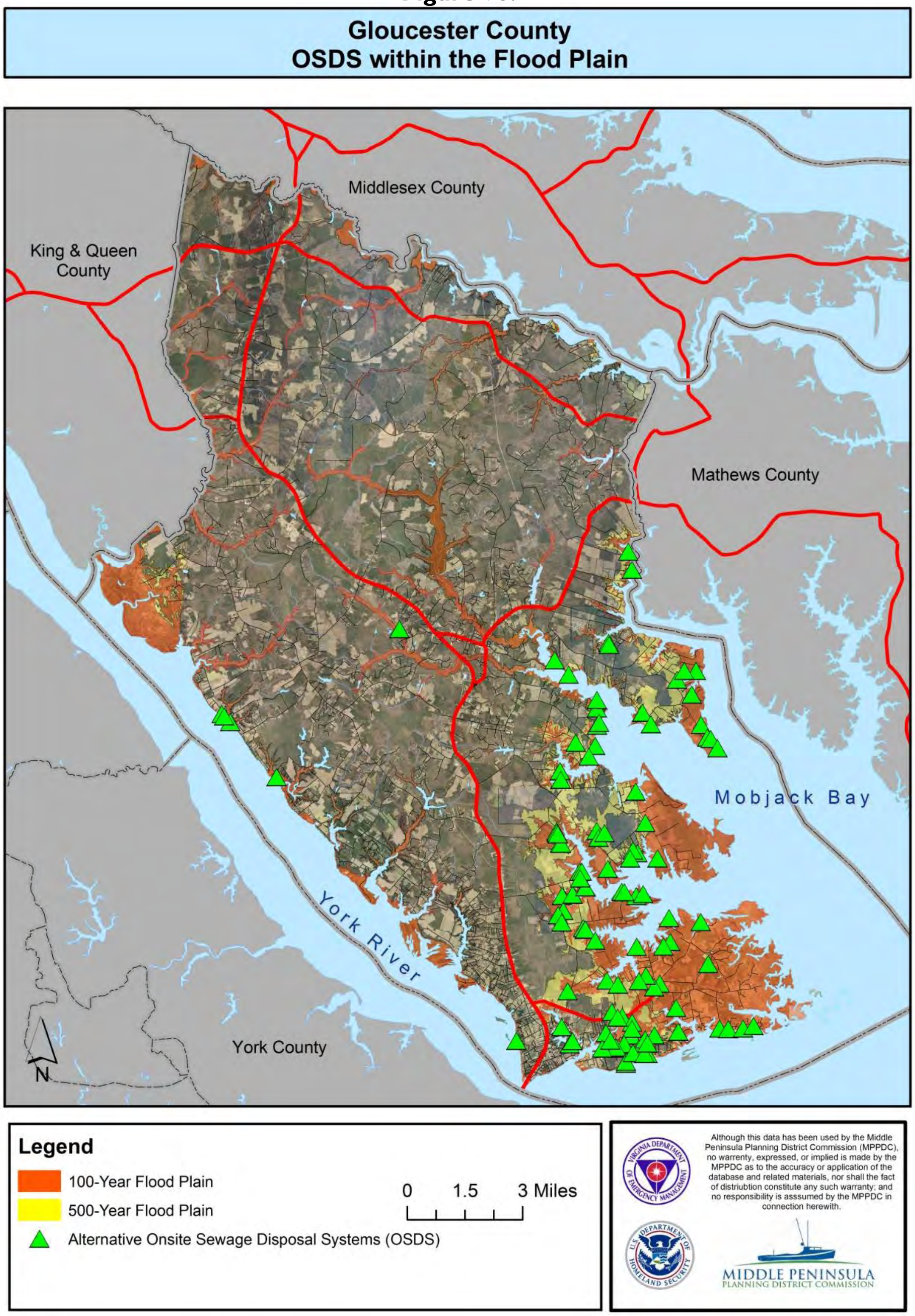
PLANNING DISTRICT COMMISSION

Figure 75:


Gloucester County
Block Group 10054
Severn River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures Zone A
Affected Structures Zone AE
Affected Structures Zone VE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Alternative On-site Sewage Disposal Systems (OSDS)
The following maps show the locations of the installed OSDS facilities constructed in the 100-year ancd 500-year floodplain in Gloucester County.

Figure 76:



4.5.5. Mathews Critical Facilities and Public Utilities

New Point Comfort Lighthouse, located at the southern tip of Mathews County, has undergone significant flood damage resulting from the lighthouse being separated from the mainland due to severe erosion. Mathews County owns the lighthouse facility and the locality has plans to undertake stabilization work to "weather-harden" the base/foundation of the structure.

According to VDOT officials, flood prone roads in Mathews County include the following:

Table 16: Mathews County Flood Prone Roads

Route	Road Name	Location
610	Marsh Hawk Road	From Rte. 614 to Rte. 611
600	Circle Drive	From Rte.14 to Rte. 14
600	Light House or Point Road	From Rte. 14 to ESM
611	Tabernacle Road	From Rte. 613 to Rte. 609
611	Tabernacle Road	From Rte. 610 to Rte. 609
609	Bethel Beach Road	From Rte. 610 to ESM
609	Bethel Beach Road	From Rte. 614 to Rte. 611
643	Haven Beach Road	From Rte. 704 to ESM
633	Old Ferry Road	From Rte. 704 to 636
608	Potato Neck Road	From Rte. 649 to ESM
644	Bandy Ridge Road	From Rte. 611 to Rte. 614

Repetitive and Severe Repetitive Loss Residential Structures in Mathews County

According to FEMA's records, there are 155 residential properties on the Repetitive Loss List and 1 on the Severe Repetitive Loss List as of 5/31/10. These properties are listed in Appendix # at the end of this document.

Public School Properties

During a Category 2 hurricane, the Thomas Hunter Middle School and the Lee Jackson Elementary School properties become flooded.

Properties In 100-year Floodplain by Census Block Groups

The following series of maps show the location of structures in Mathews County that are in Flood Zone AE or Flood Zone VE in the 100-year and 500-year floodplains. The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 77:

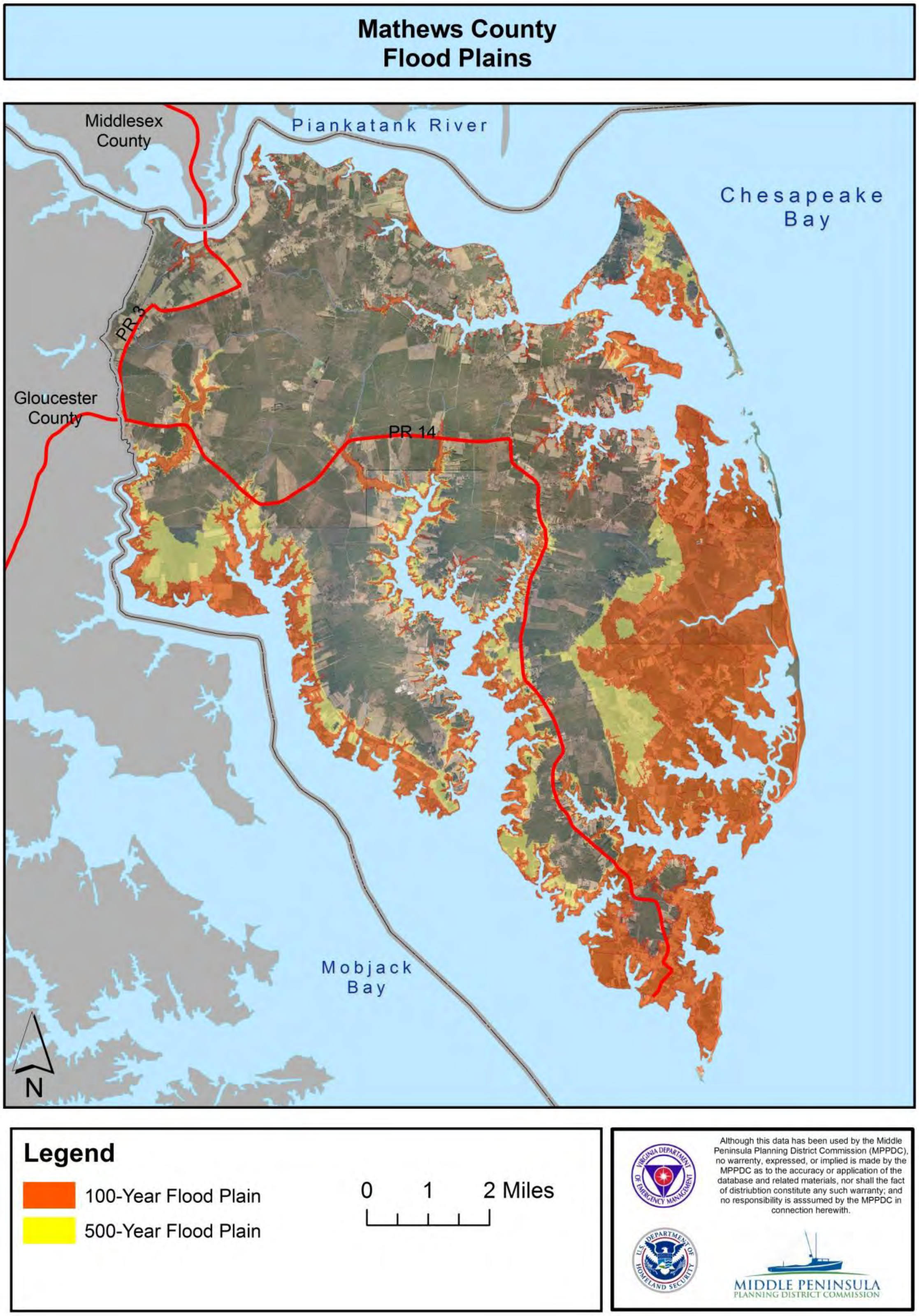

Mathews County
Flood Plains
Middlesex County
Piankatank River
Chesapeake Bay
PR 3
Gloucester County
PR 14
Mobjack Bay
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 78:


Mathews County
Census Block Groups
Middlesex County
Piankatank River
Chesapeake Bay
PR 3
Gloucester County
PR 14
Mobjack Bay
N
Legend
Census Block Groups
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 79:

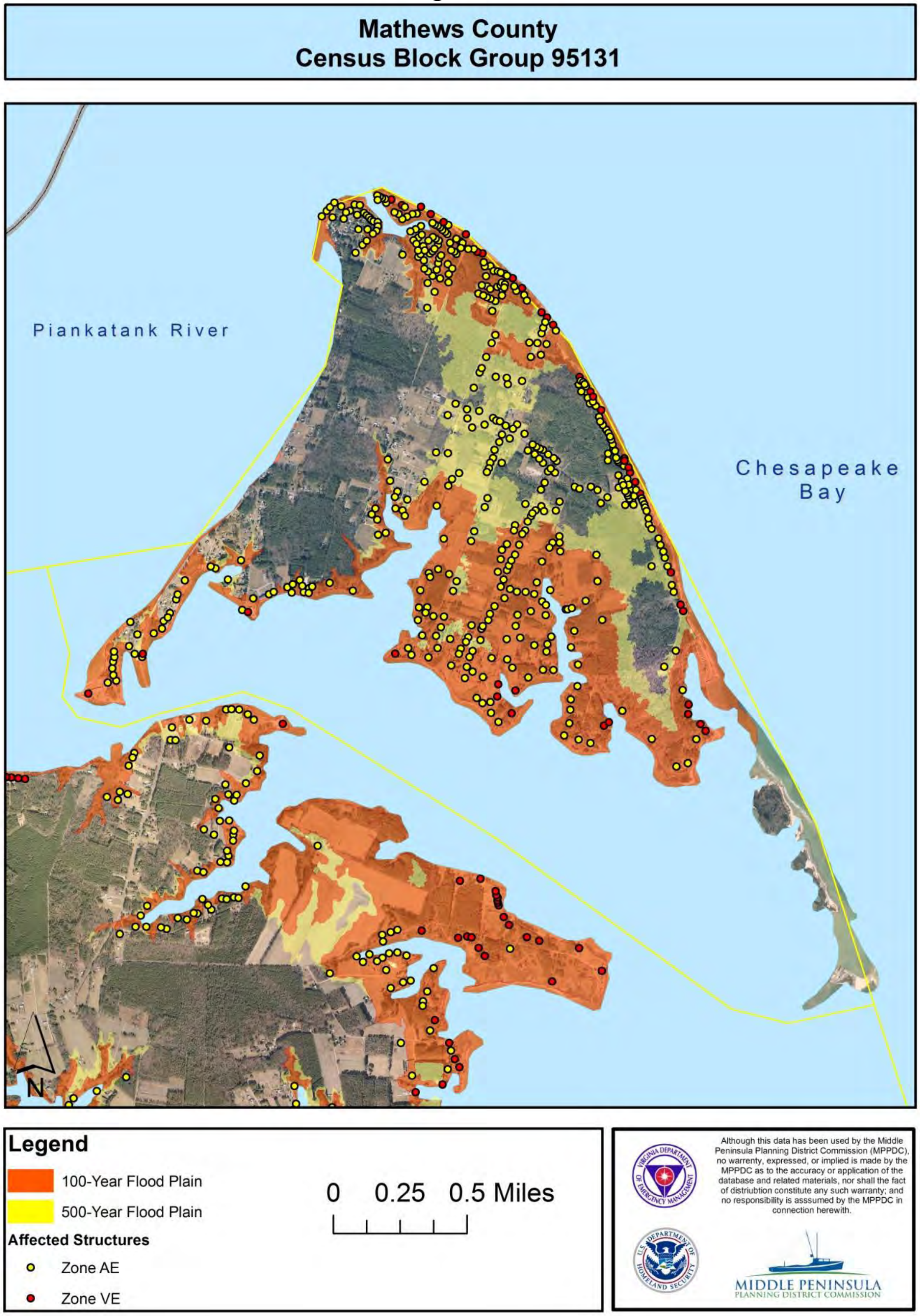

Mathews County
Census Block Group 95131
Piankatank River
Chesapeake Bay
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone AE
Zone VE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 80:

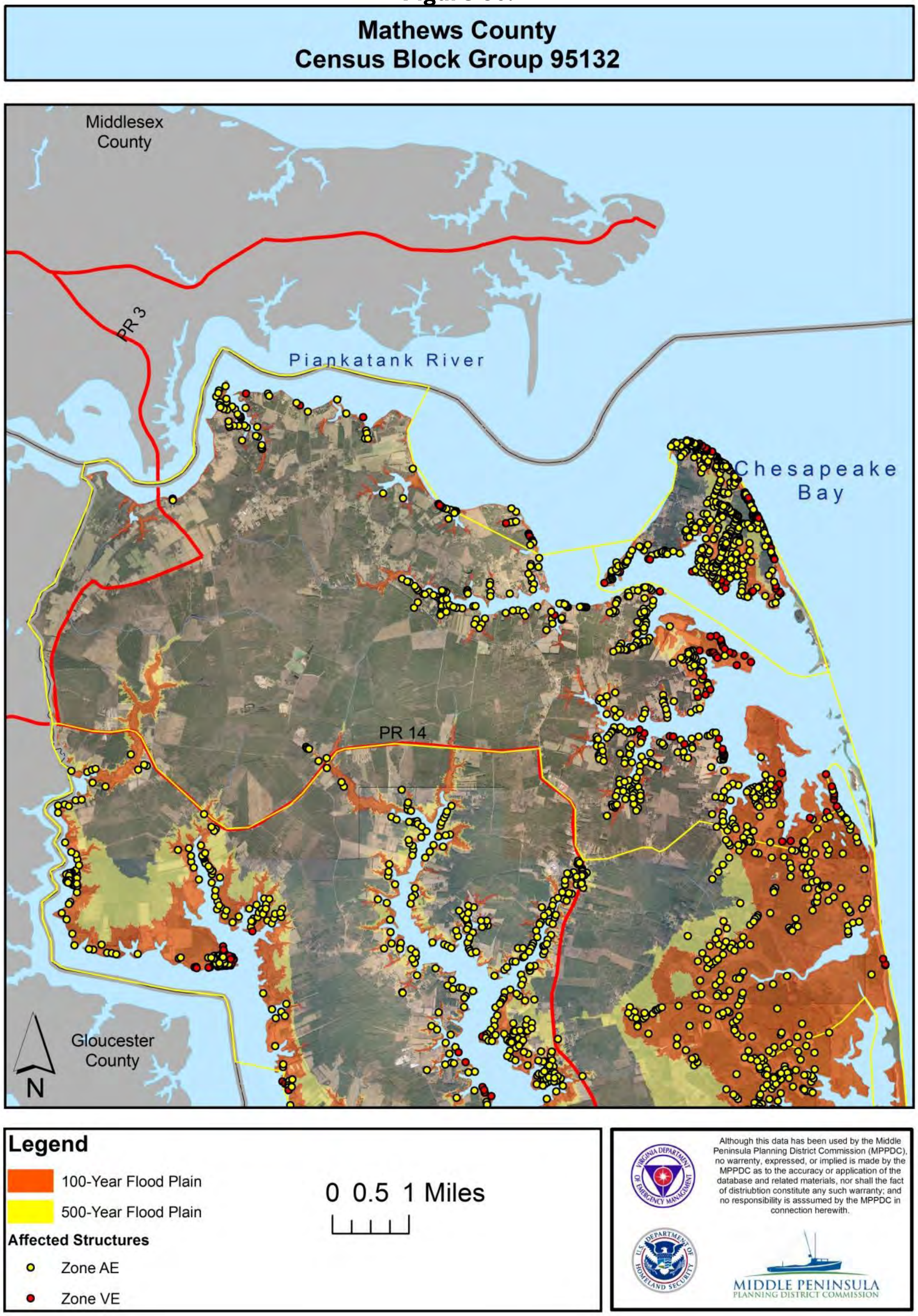

Mathews County
Census Block Group 95132
Middlesex County
PR 3
Piankatank River
Chesapeake Bay
PR 14
Gloucester County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone AE
Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA PLANNING DISTRICT COMMISSION

Figure 81:

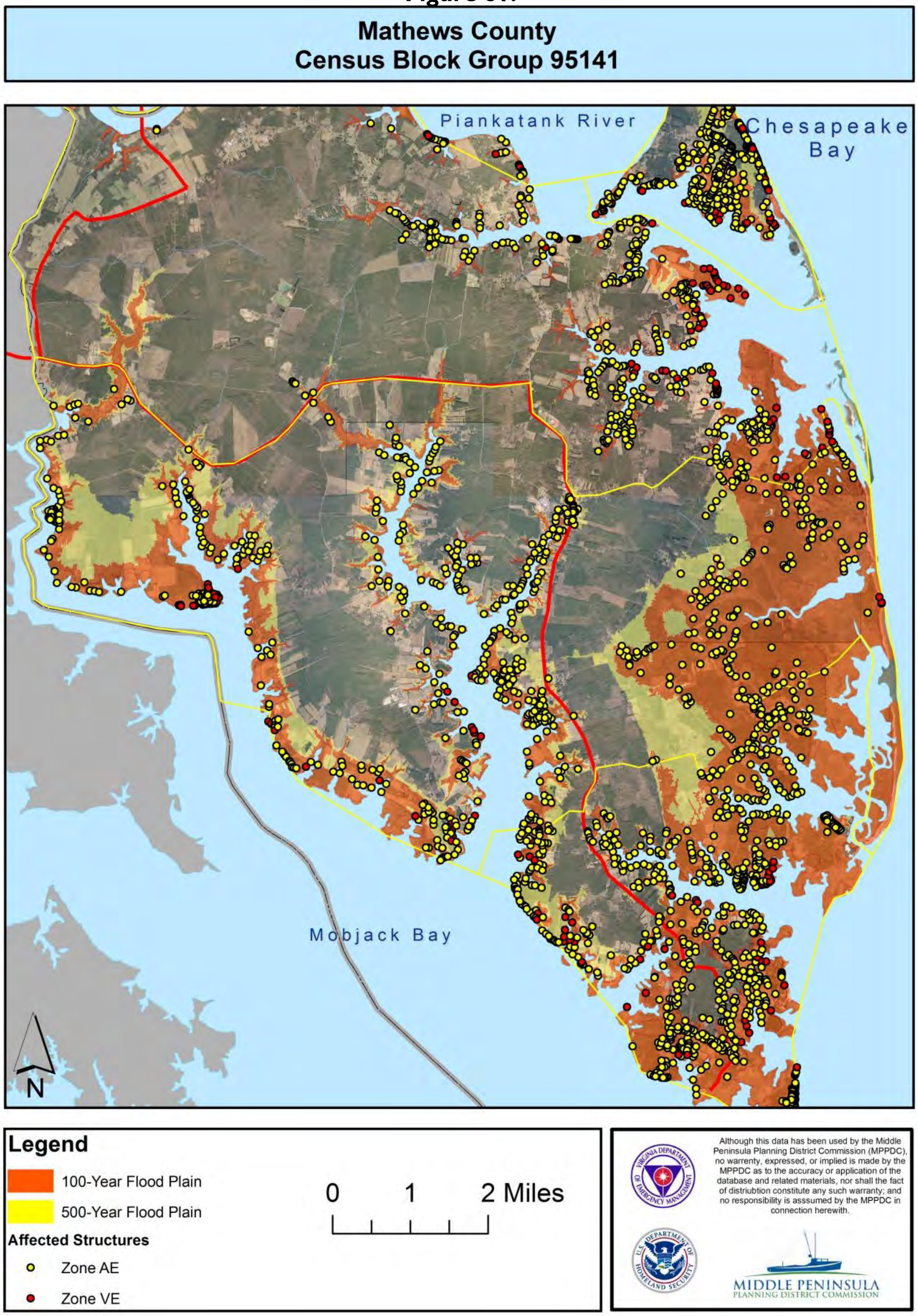
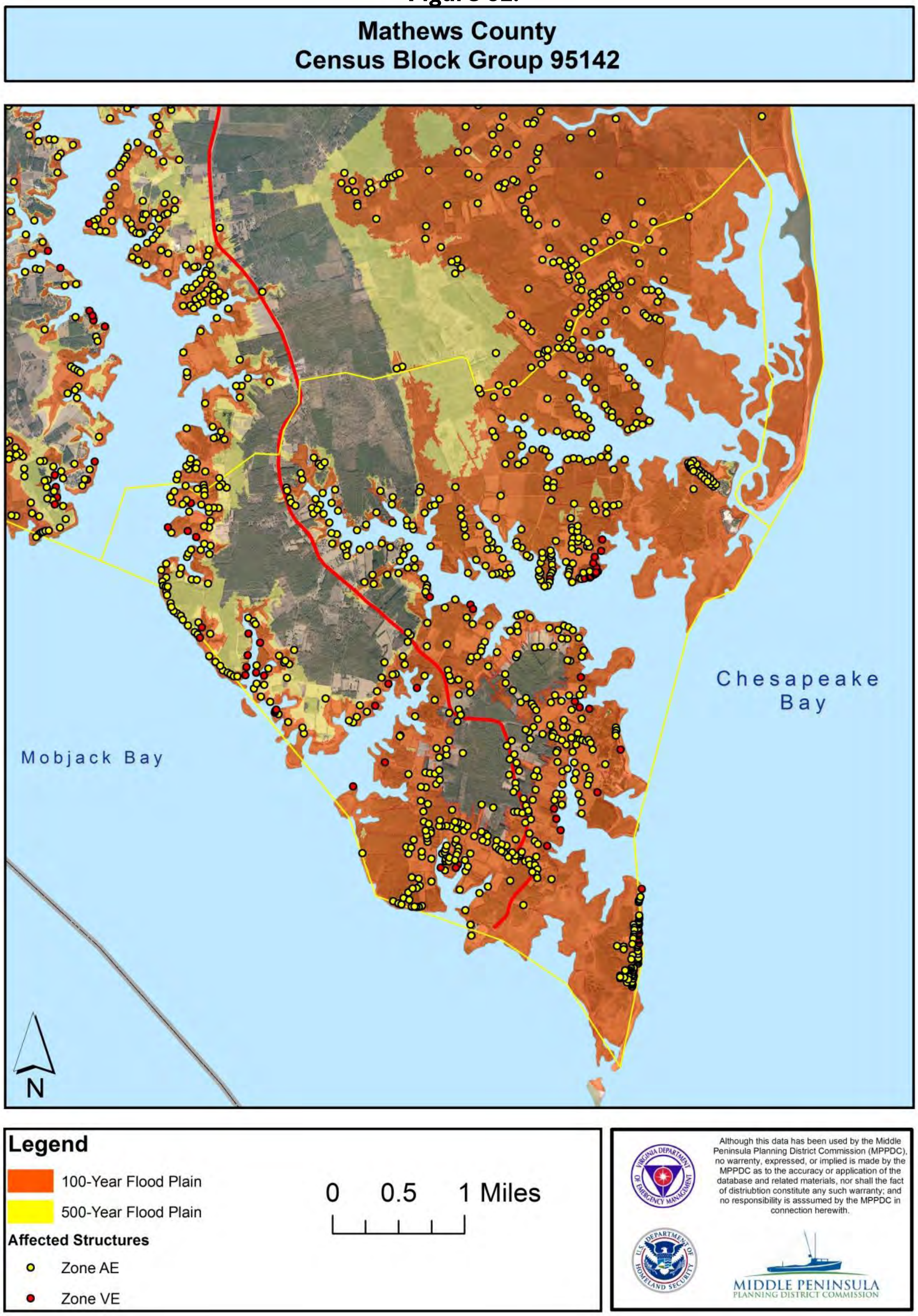
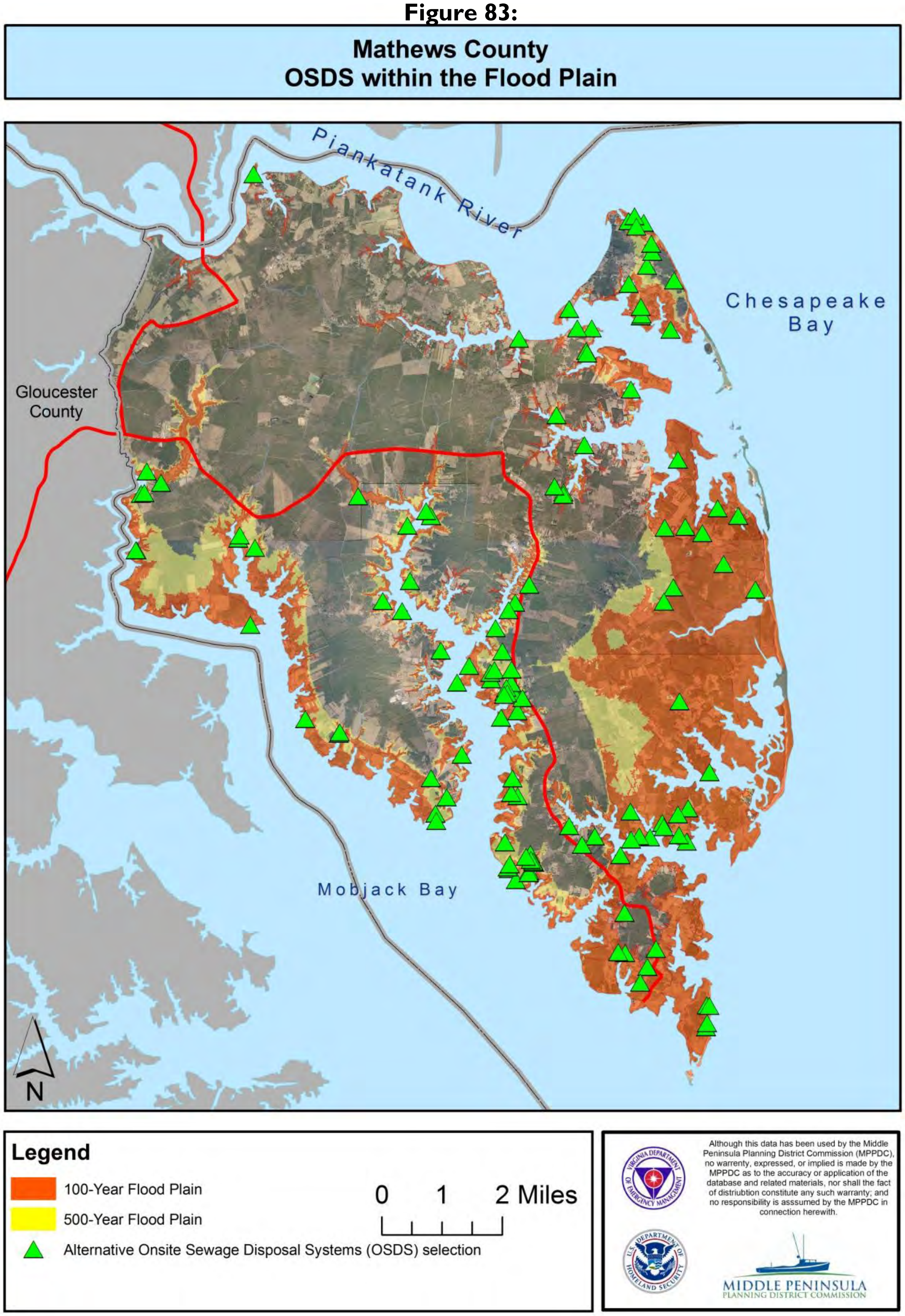

Mathews County
Census Block Group 95141
Piankatank River
Chesapeake Bay
Mobjack Bay
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone AE
Zone VE
0 1 2 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 82:


Mathews County
Census Block Group 95142
Chesapeake Bay
Mobjack Bay
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone AE
Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Alternative On-site Sewage Disposal Systems (OSDS)
The following maps show the location of the OSDS facilities constructed in the 100-year and 500-year floodplains in Mathews County.

Figure 83:



4.5.6. Middlesex County Critical Facilities and Public Utilities

The county does not currently operate any public water systems. However, there are community water systems operated by private companies serving the Village of Saluda and some of the larger residential subdivisions in the lower portion of the county in the Hartfield and Deltaville areas. These water systems do not sustain flood damages from severe hurricanes and nor'easters.

The County does have a public sewerage system in the planning stages that will serve the Village of Saluda and properties east along the Route 33 corridor towards the Cook's Corner area. The wastewater treatment plant and outfall for this proposed system will be built along a tributary of Urbanna Creek, located between Saluda and Cook's Corner.

Since this project is in the permitting/design stage, it is assumed that the facility will be designed and constructed in a manner to avoid any future adverse impacts from floodwaters.

According to VDOT officials, flood prone roads in Middlesex County/Urbanna include the following:

Table 17: Middlesex County/Urbanna Flood Prone Roads

Route	Road Name	Location
648	Montague Island Road	From Rte.604 to ESM
651	Smokey Point	From Rte. 640 to Rte. 685
1103	Irma's Lane	From Rte. 33 to Rte. 1102
628	Mill Creek Road	From Rte. 702 to ESM
636	Timber Neck Road	From Rte. 643 to Rte. 659

Repetitive and Severe Repetitive Loss Residential Structures in Middlesex County

According to FEMA's records, there are 32 residential properties on the Repetitive Loss List and 0 on the Severe Repetitive Loss List as of 5/31/10. These properties are listed in Appendix # at the end of this document.

Properties in 100-year Floodplain by Census Block Group

The following series of maps show the location of structures in Middlesex County that are in Flood Zone A, Flood Zone AE or Flood Zone VE in the 100-year and 500-year floodplains. The legend is color coded to indicate the specific flood zone in which each structure lies.

Figure 84:

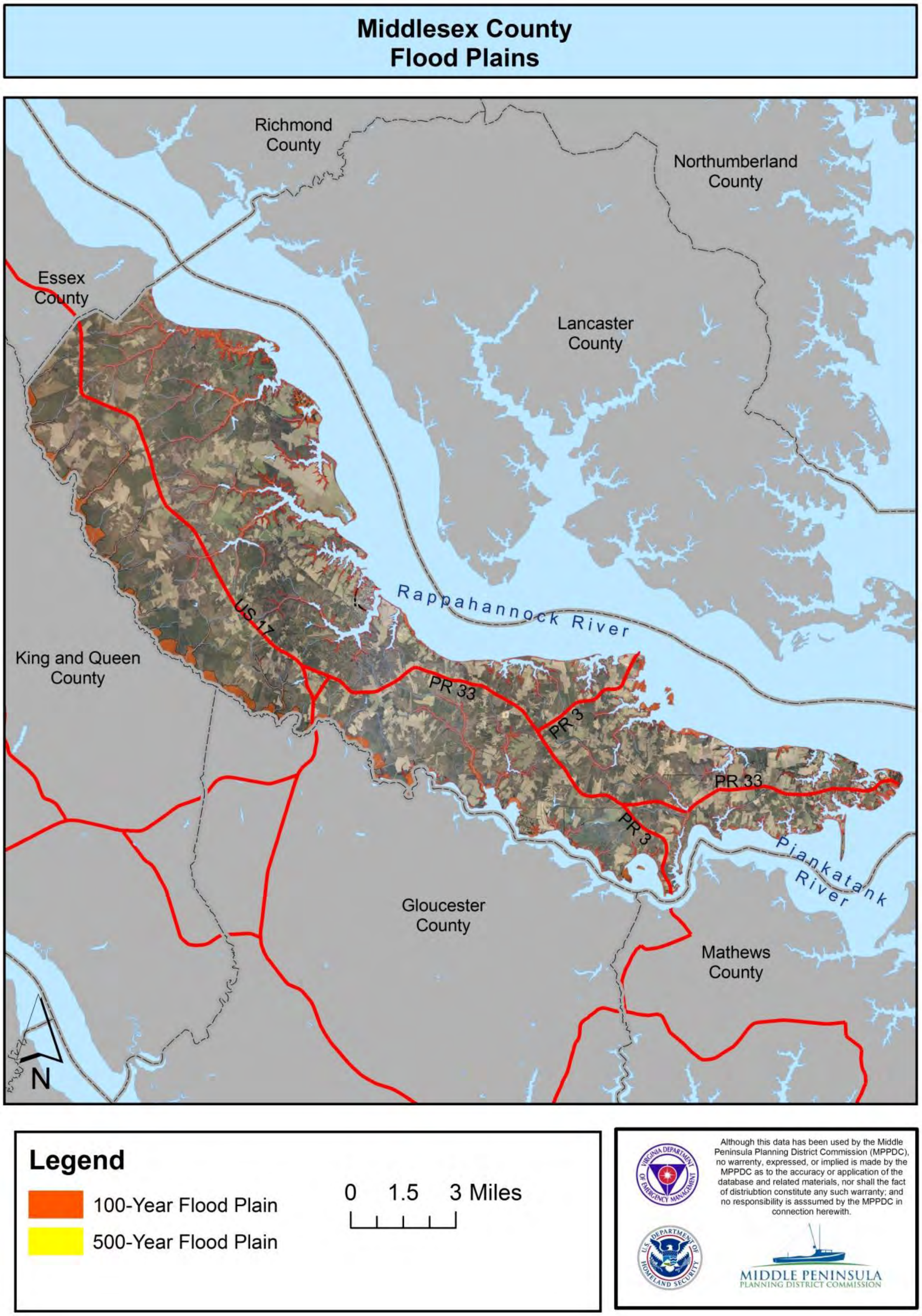

Middlesex County
Flood Plains
Richmond County
Northumberland County
Essex County
Lancaster County
Rappahannock River
US 17
King and Queen County
PR 33
PR 3
PR 33
PR 3
Piankatank River
Gloucester County
Mathews County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
0 1.5 3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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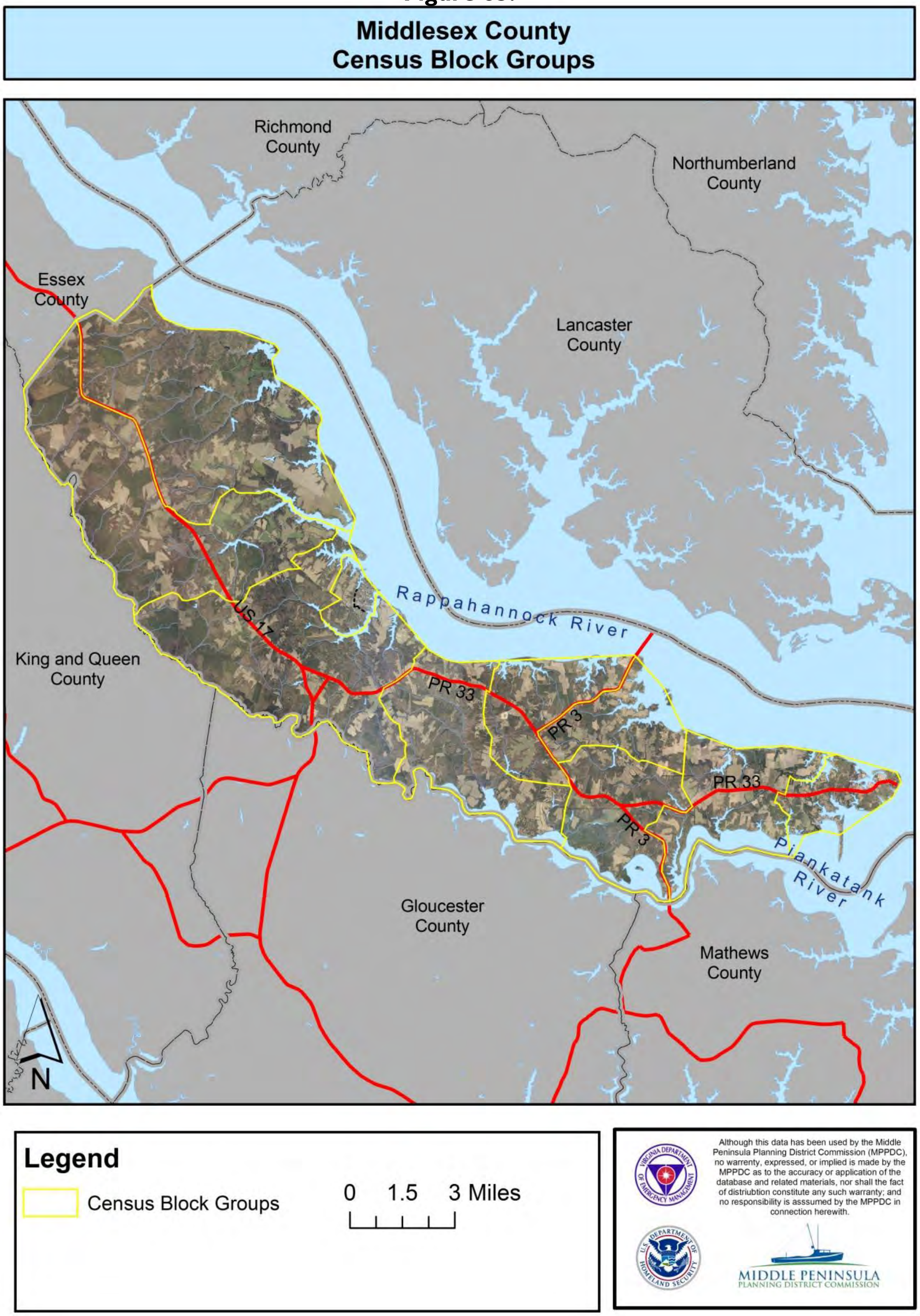
Figure 85:



Middlesex County
Census Block Groups
Richmond County
Northumberland County
Essex County
Lancaster County
Rappahannock River
US 17
PR 33
PR 3
King and Queen County
PR 33
PR 3
Piankatank River
Gloucester County
Mathews County
N
Legend
Census Block Groups
0 1.5 3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 86:

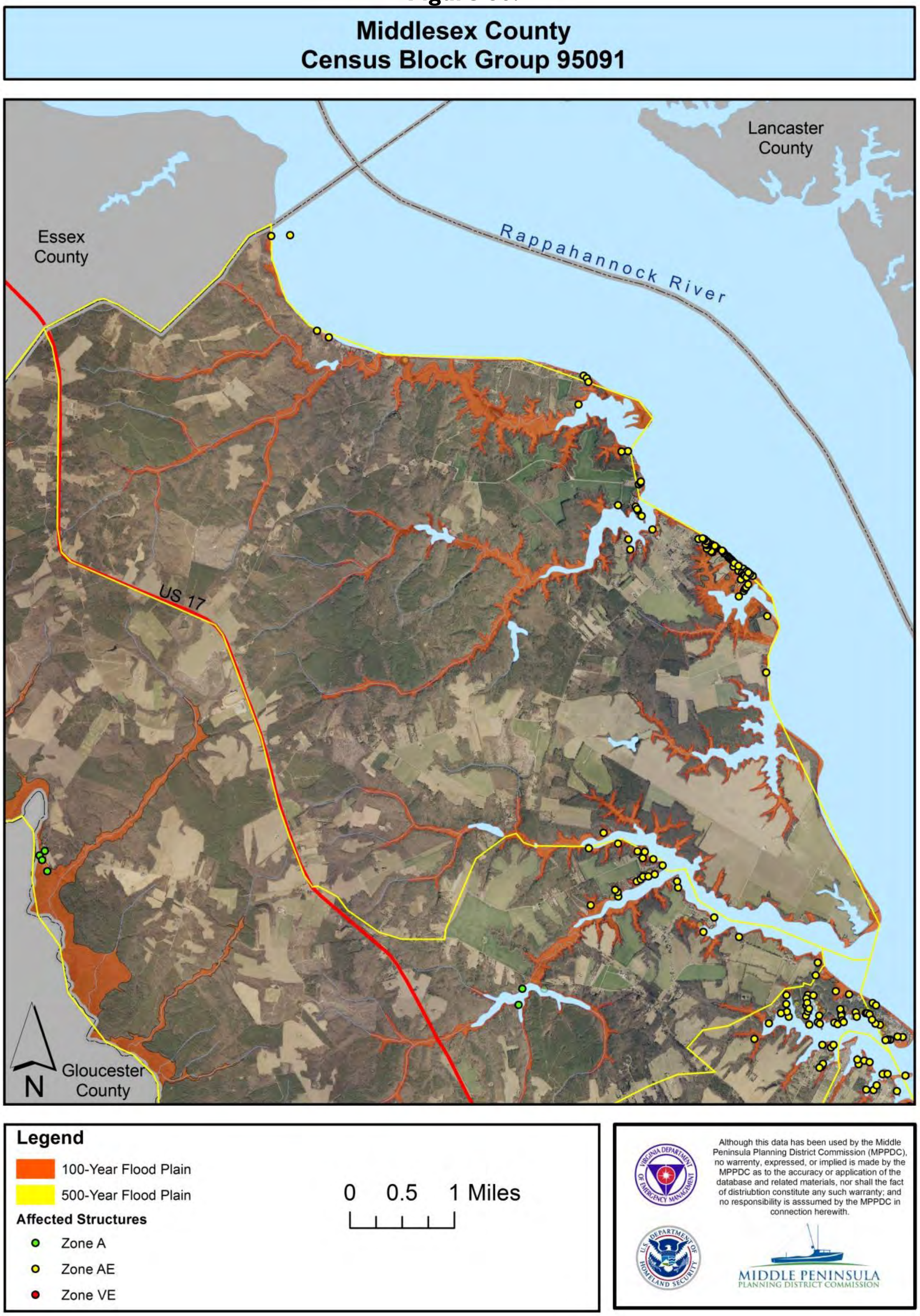

Middlesex County
Census Block Group 95091
Lancaster County
Essex County
Rappahannock River
US 17
Gloucester County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
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Figure 87:

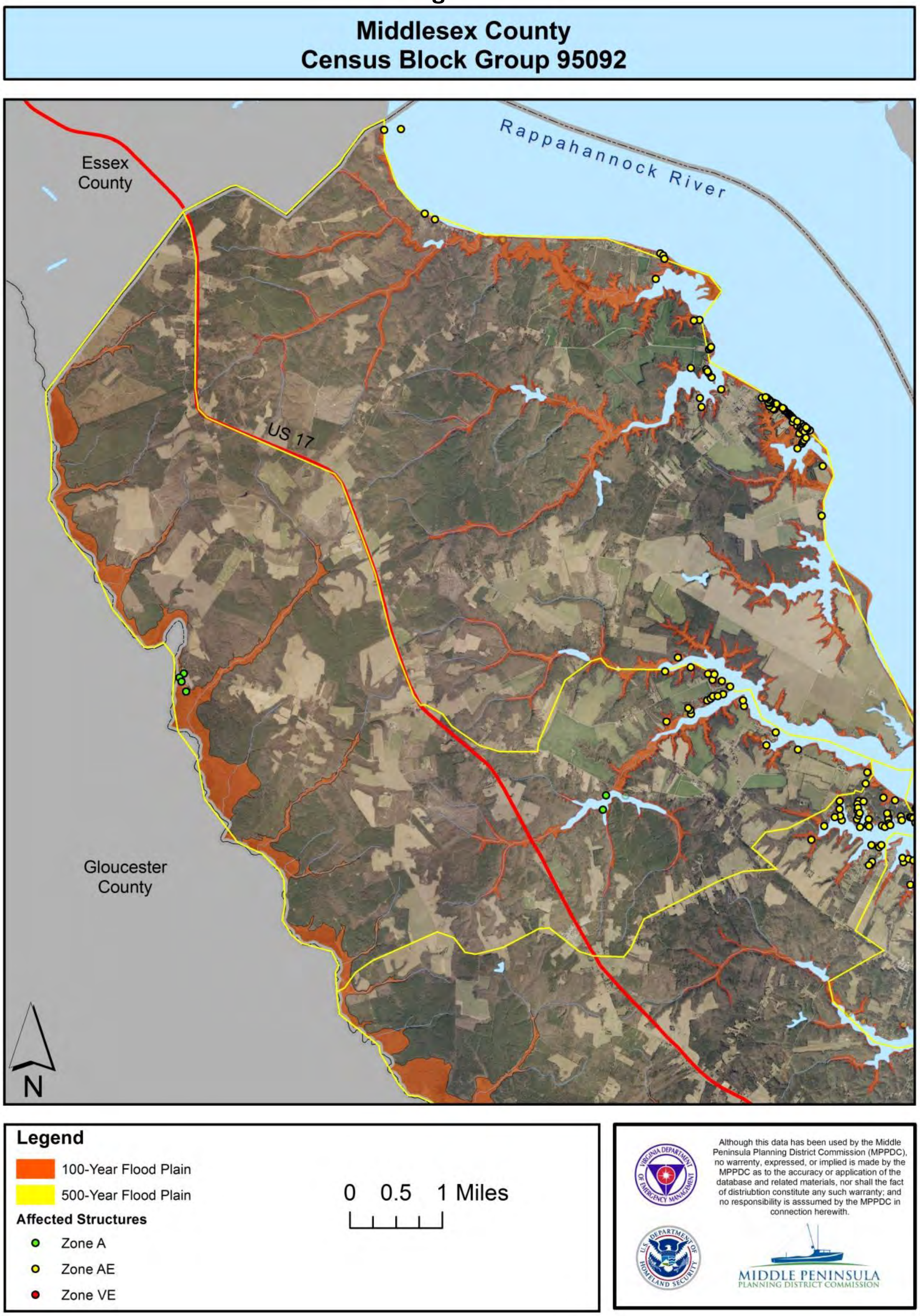
Middlesex County
Census Block Group 95092
Rappahannock River
Essex County
US 17
Gloucester County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 88:

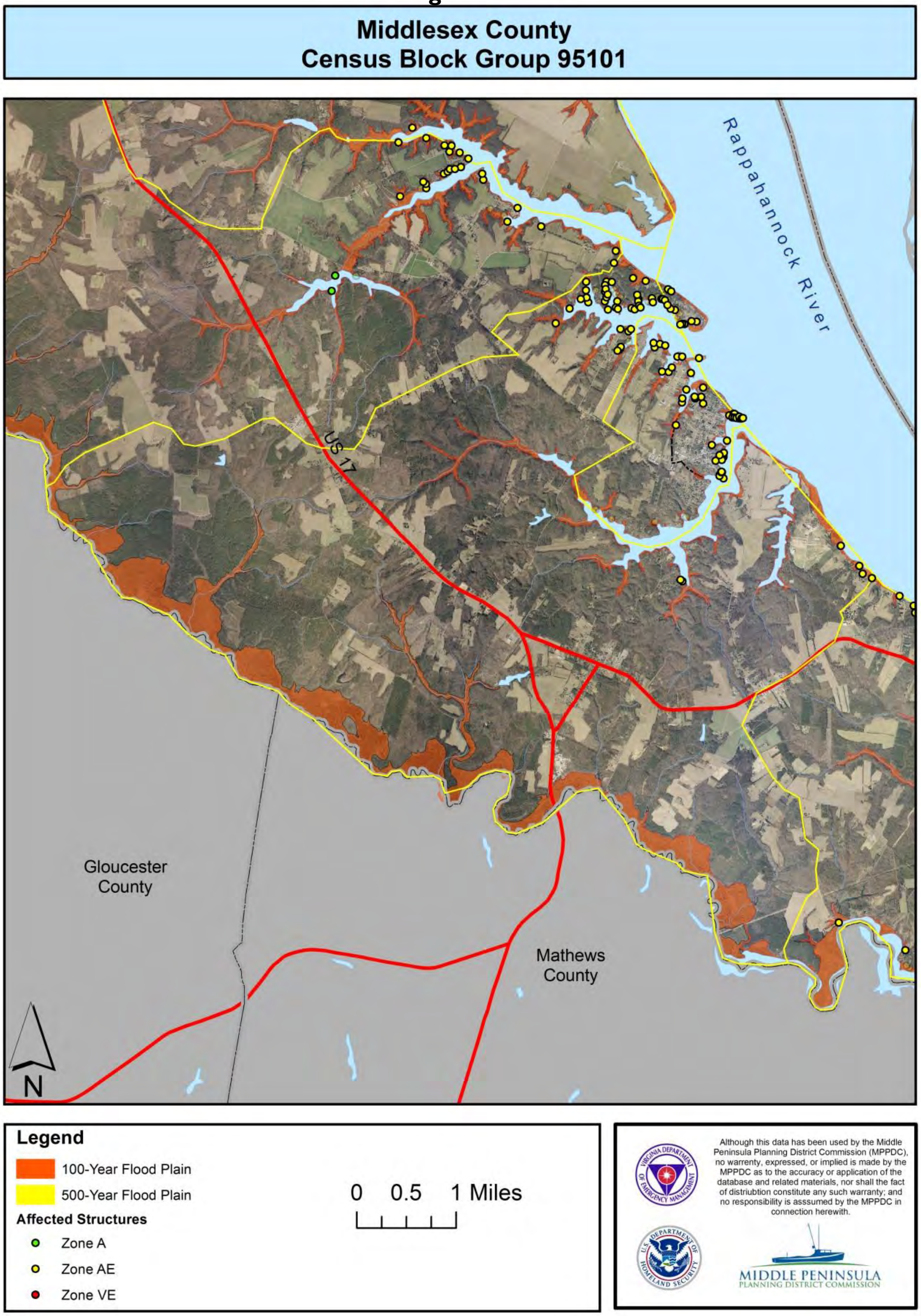
Middlesex County
Census Block Group 95101
Rappahannock River
US 17
Gloucester County
Mathews County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.5 1 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 89:

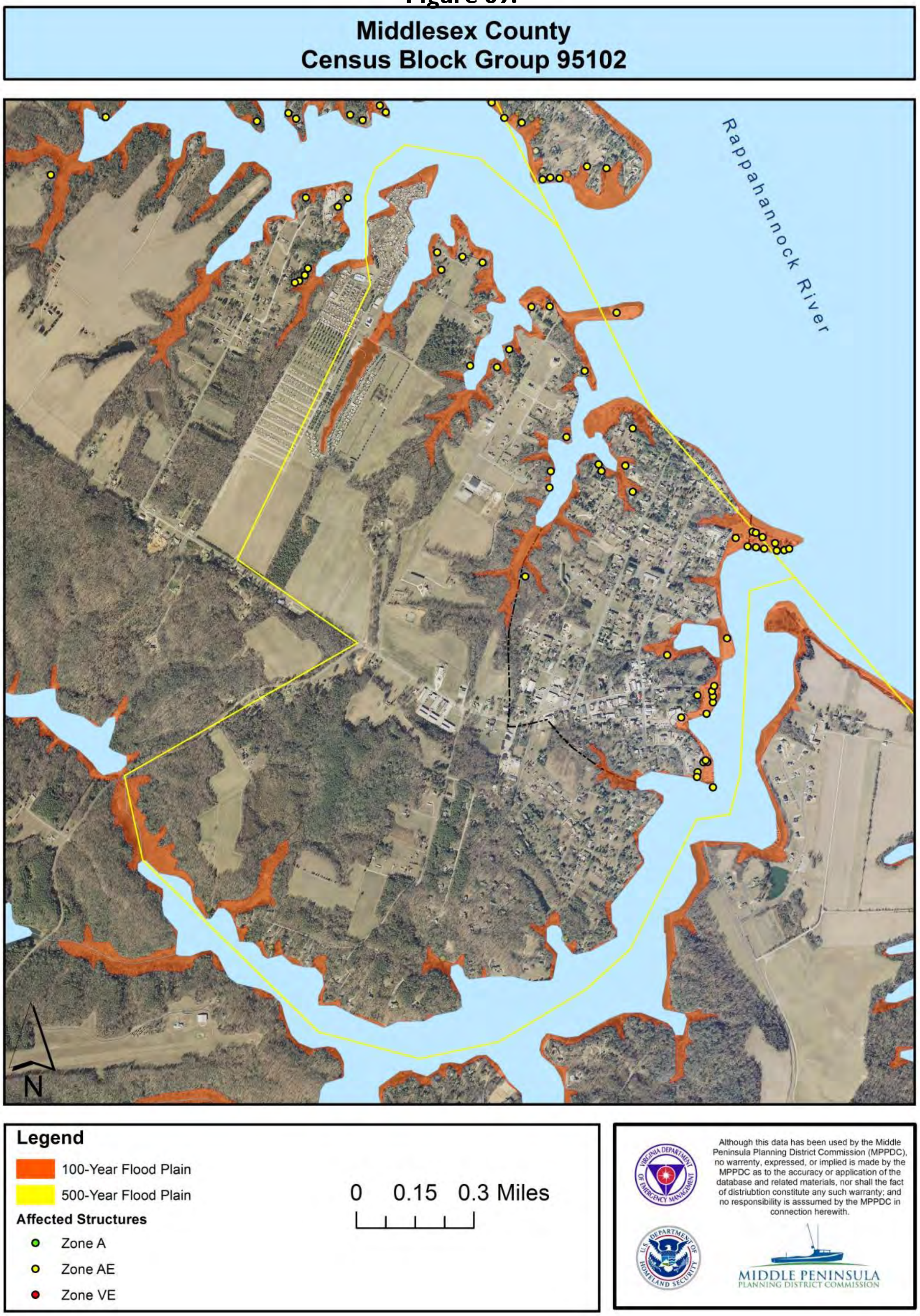
Middlesex County
Census Block Group 95102
Rappahannock River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.15 0.3 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warranty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
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Figure 90:

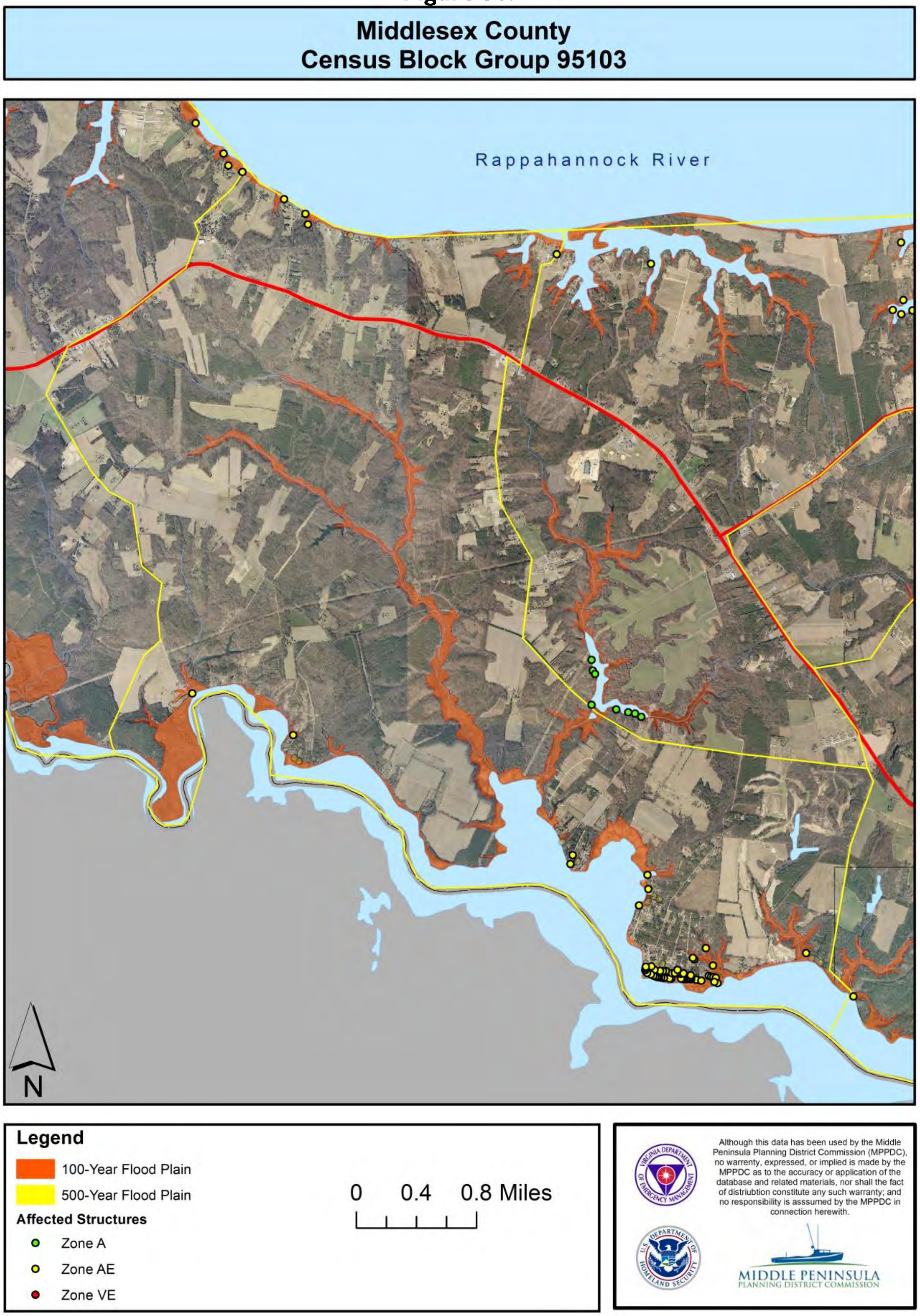
Middlesex County
Census Block Group 95103
Rappahannock River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.4 0.8 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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Figure 91:

Middlesex County
Census Block Group 95111
Rappahannock River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.3 0.6 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Figure 92:

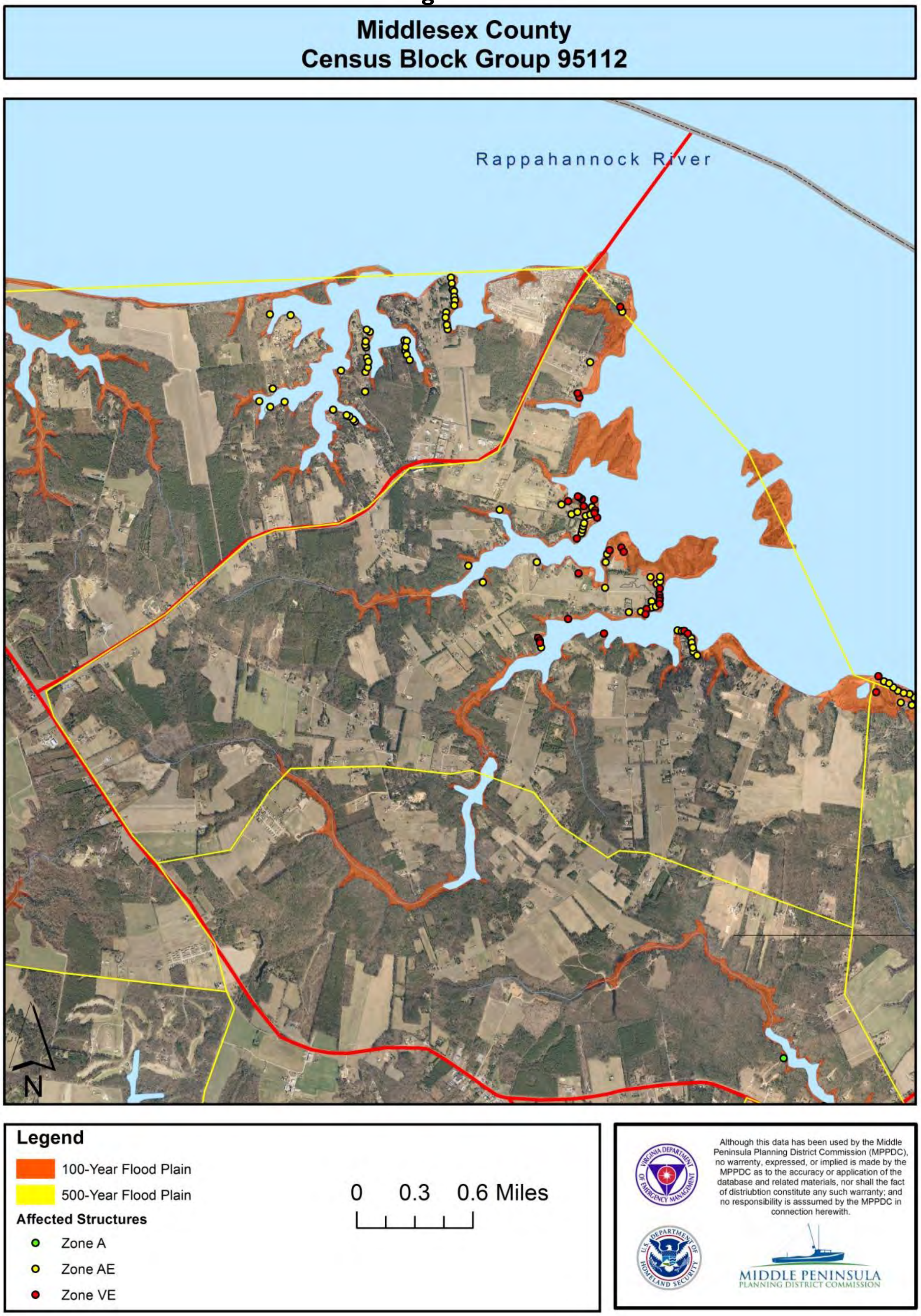
Middlesex County
Census Block Group 95112
Rappahannock River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.3 0.6 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
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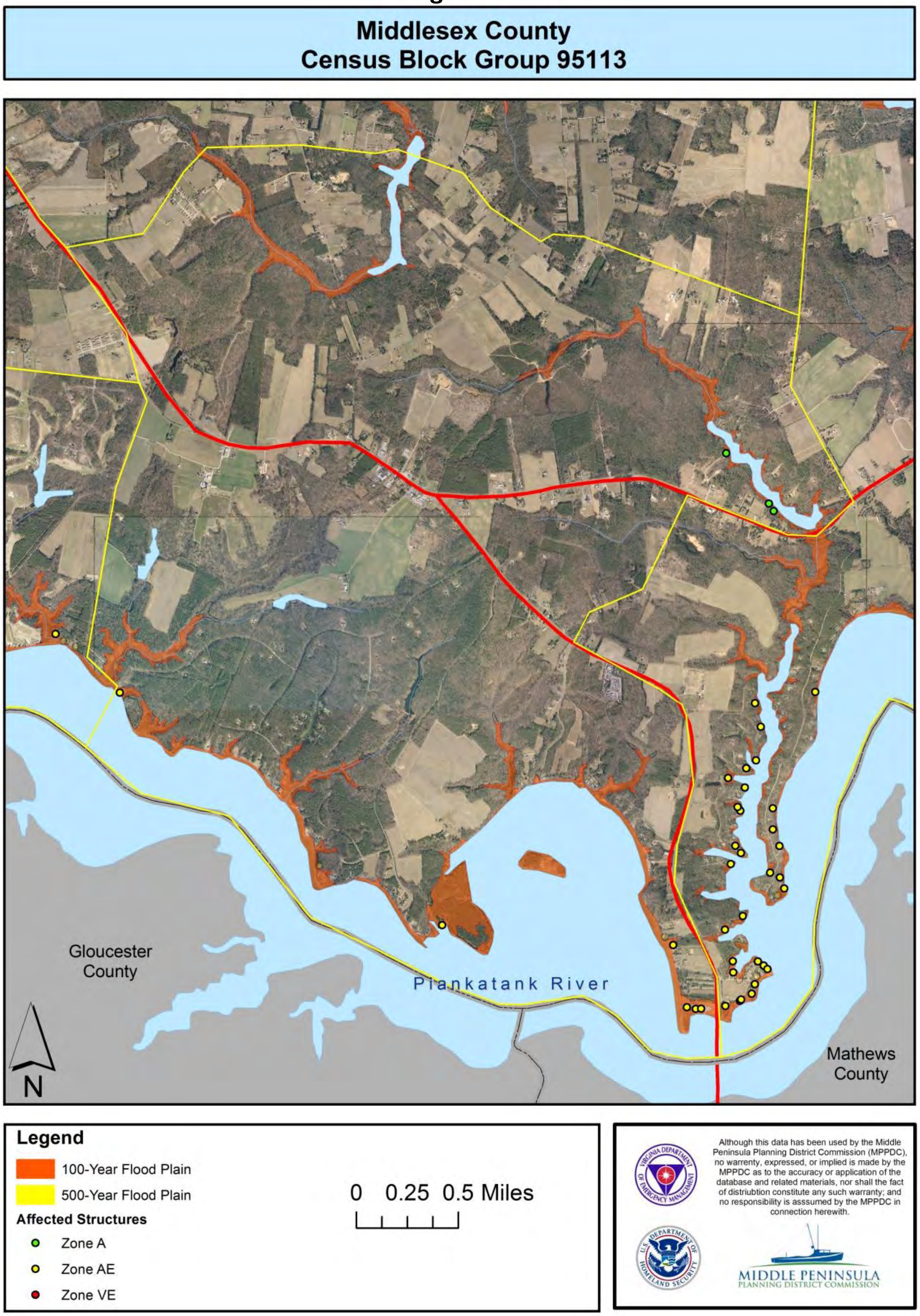
Figure 93:


Middlesex County
Census Block Group 95113
Gloucester County
Piankatank River
Mathews County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
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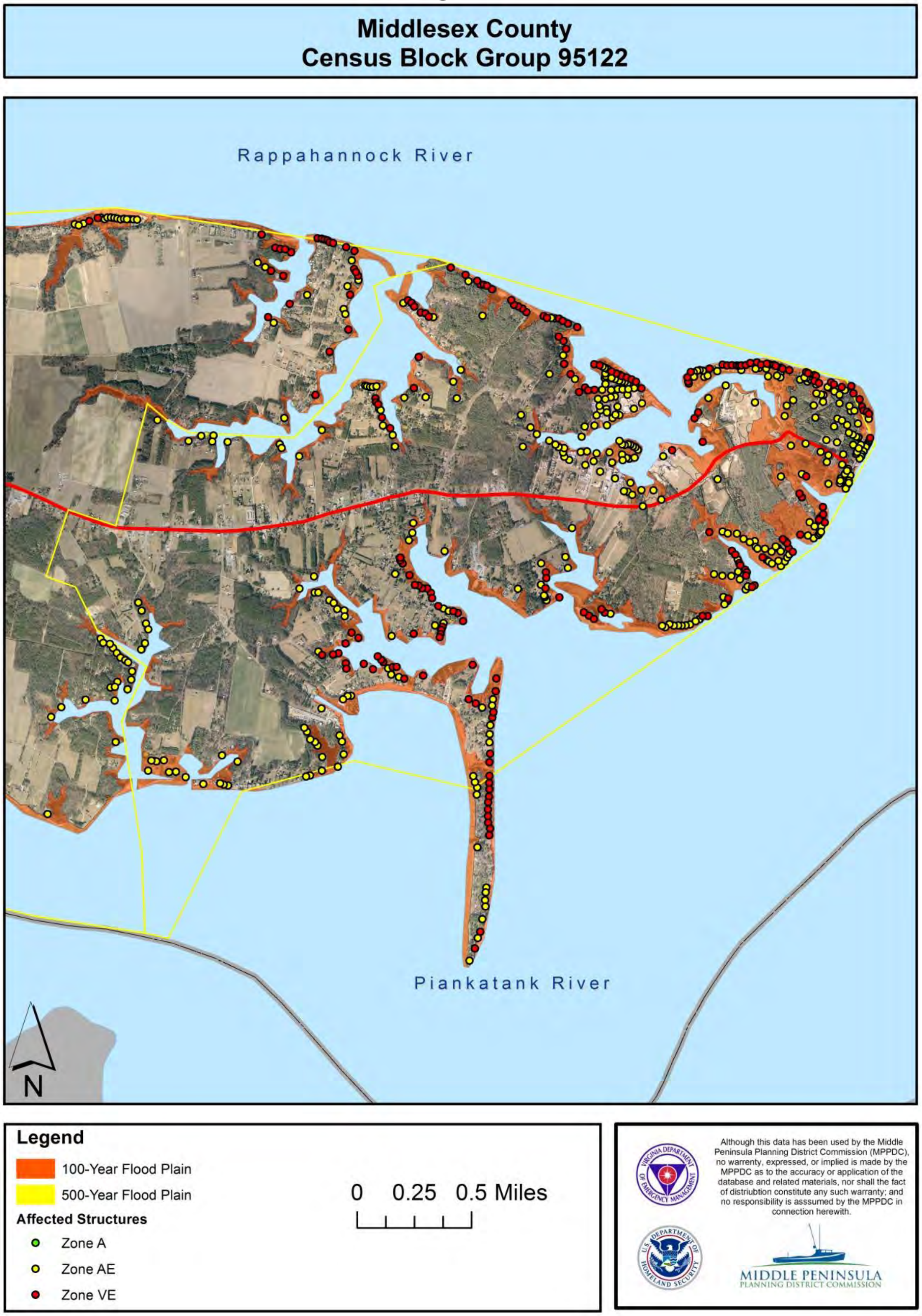
PLANNING DISTRICT COMMISSION

Figure 94:


Middlesex County
Census Block Group 95121
Rappahannock River
Piankatank River
Mathews County
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.375 0.75 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

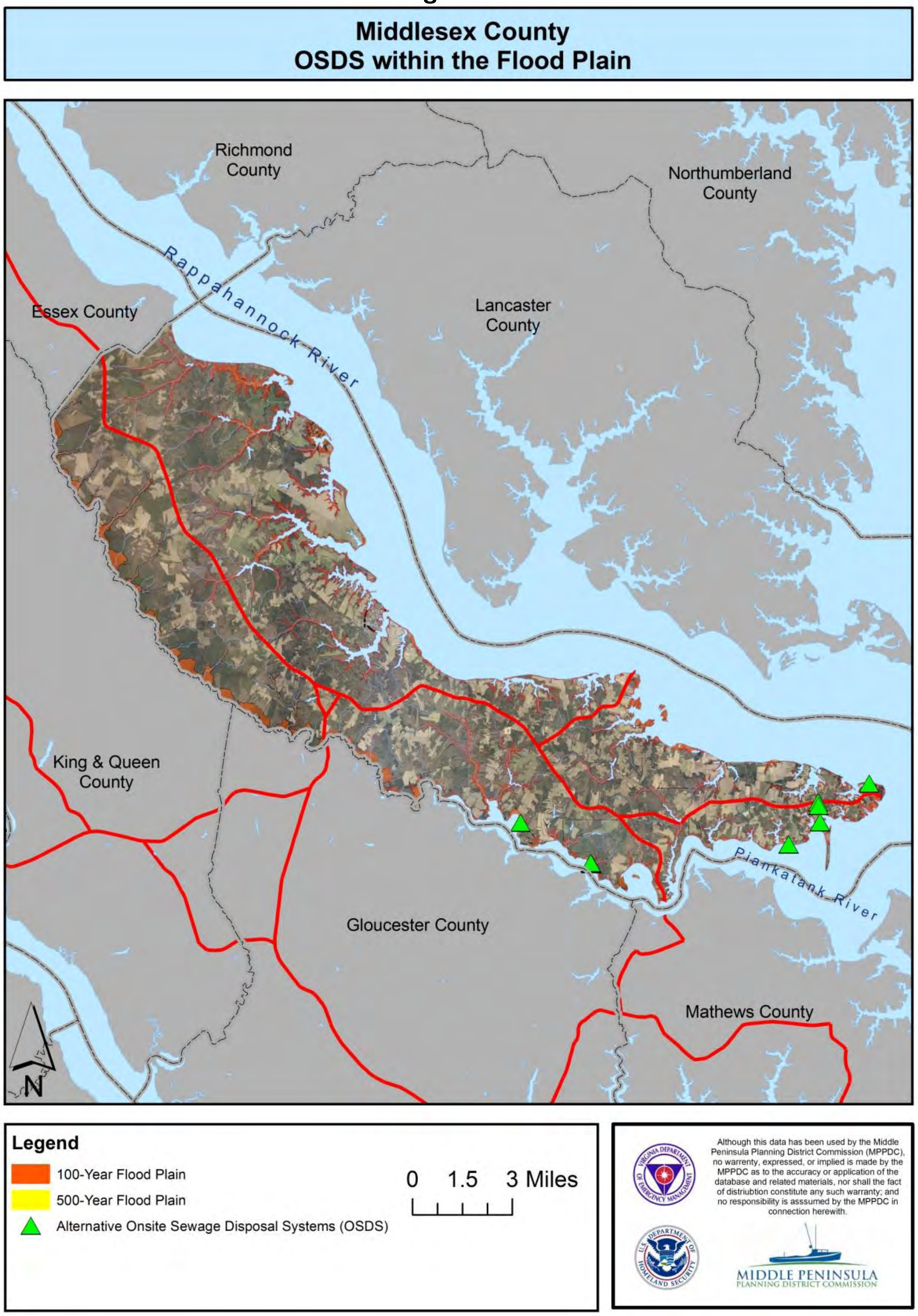
Figure 95:


Middlesex County
Census Block Group 95122
Rappahannock River
Piankatank River
N
Legend
100-Year Flood Plain
500-Year Flood Plain
Affected Structures
Zone A
Zone AE
Zone VE
0 0.25 0.5 Miles
Although this data has been used by the Middle Peninsula Planning District Commission (MPPDC), no warrenty, expressed, or implied is made by the MPPDC as to the accuracy or application of the database and related materials, nor shall the fact of distriubtion constitute any such warranty; and no responsibility is asssumed by the MPPDC in connection herewith.
MIDDLE PENINSULA
PLANNING DISTRICT COMMISSION

Alternate On-site Sewage Disposal Systems (OSDS)

The maps below show the location of the OSDS facilities constructed in the 100-year and 500-yer floodplain in Middlesex County.

Figure 96:



Urbanna Critical Facilities and Public Utilities
The Town of Urbanna provides public water and sewer service to its residents. The town operates the public water system which serves town residents as well as some nearby customers in surrounding Middlesex County.

The sewerage collection and treatment system is operated by the Hampton Roads Sanitation District (HRSD). When flood waters are anticipated, the staff at HRSD turn off the pumps at the sewerage pump stations in order to prevent pumping floodwaters into the wastewater treatment plant.

The wastewater treatment plant is located on high land next to the town's water tower, which is an area that does not flood.

The town operates the Urbanna Town Marina that includes a boat/fishing dock, a small beach area, a small park and a small operations building - all located at Upton's Point along the Rappahannock River. This facility suffered significant damage in 2003 from Hurricane Isabel and has been completely rebuilt since then at an approximate cost of $850,000.

Repetitive and Severe Repetitive Loss Residential Structures in the Town of Urbanna
According to FEMA's records, there are 2 residential properties on the Repetitive Loss List and 0 on the Severe Repetitive Loss List as of 5/31/10.

In 2003, Hurricane Isabel damaged/destroyed 5 houses along low-lying Island Drive. When these houses were re-built by the property owners, they were elevated in order to prevent future damage from flood waters along this section of the Rappahannock River.

Appendix 8 – Tornado History in the Middle Peninsula Region (1950-2014)

Date	Time	Affected Counties	Fujita	Fatalities	Injuries	Width (yards)	Length (miles)	Damage	Touch Latitude	Touch Longitude	Lift Latitude	Lift Longitude
5/11/1951	3:00 PM	King and Queen	1	0	0	10	0.1	$5K-$50K	37.55	-76.73	-	-
6/26/1954	7:00 PM	Essex	?	0	0	10	0.1	$500-$5000	37.93	-76.87	-	-
4/25/1975	4:00 PM	Gloucester, Mathews	1	0	4	10	4	$50K-$500K	37.47	-76.48	37.5	-76.42
7/13/1975	7:20 PM	King William	0	0	0	10	0.1	$50-$500	37.77	-77.17	-	-
8/14/1975	7:10 PM	Gloucester	0	0	0	27	0.2	$500-$5000	37.42	-76.53	-	-
8/24/1975	10:30 PM	Gloucester	1	0	0	27	0.1	$500-$5000	37.3	-76.53	-	-
7/15/1976	5:00 PM	Middlesex	1	0	0	10	0.1	-	37.67	-76.58	-	-
9/5/1979	3:30 PM	Gloucester	1	0	0	20	0.5	$5K-$50K	37.23	-76.48	-	-
5/24/1980	4:50 PM	Gloucester	1	0	0	27	0.6	$500-$5000	37.55	-76.53	-	-
5/11/1981	5:30 PM	Middlesex	2	0	0	20	0.2	$5K-$50K	37.68	-76.68	-	-
3/30/1989	3:15 PM	Mathews	1	0	0	150	3	$50K-$500K	37.33	-76.32	37.35	-76.27
10/18/1990	3:00 PM	King William	3	1	0	430	5	$500K-$5M	37.62	-77.1	37.67	-77.05
8/6/1993	12:00 PM	Middlesex	3	0	0	100	2.9	$5K-$50K	37.58	-76.58	-	-
10/5/1995	11:20 AM	King and Queen	1	0	0	150	3	$50K-$500K	37.52	-76.77	37.55	-76.75
7/12/1996	9:05 PM	Gloucester	0	0	0	50	0.5	$10,000	37.28	-76.4	37.28	-76.4
7/12/1996	9:15 PM	Gloucester	0	0	0	50	0.5	$10,000	37.48	-76.62	37.48	-76.62
7/15/1996	5:30 PM	Gloucester	1	0	0	100	7	$100,000	37.27	-76.48	37.28	-76.37
3/9/1998	4:30 AM	Gloucester	0	0	0	50	1.5	$20,000	37.77	-76.42	37.28	-76.4
7/14/2000	6:09 PM	Mathews	0	0	0	20	0.5	$2,000	37.5	-76.3	37.5	-76.3
7/14/2000	5:08 PM	Middlesex	0	0	0	20	0.5	-	37.55	-76.33	37.55	-76.33
5/8/2003	1:15 PM	Essex	0	0	0	50	0.2	-	37.93	-76.85	37.93	-76.85
5/2/2004	8:30 PM	King and Queen	1	0	0	100	1	$30,000	37.67	-76.85	37.67	-76.85
9/8/2004	12:05 PM	King William	0	0	0	100	1	$10,000	37.78	-77.1	37.78	-77.1
7/8/2005	1:15 AM	Middlesex	1	0	0	50	3	$10,000	37.6	-76.6	37.6	-76.6
1/14/2006	1:15 AM	King and Queen	0	0	0	50	0.3	$10,000	37.77	-76.88	37.77	-76.88
9/28/2006	6:35 PM	King and Queen	1	0	0	100	2	$30,000	37.67	-76.8	37.67	-76.8
4/27/2007	10:30 AM	Gloucester	0	0	0	100	5.13	$50,000	37.44	-76.67	37.46	-76.58
4/20/2008	1:58 PM	King William	0	0	0	40	0.3	$10,000	37.72	-77.22	-	-
4/20/2008	4:25 PM	King William	0	0	0	40	0.3	$10,000	37.71	-77.12	-	-
4/20/2008	4:28 PM	King William	0	0	0	25	0.2	$2,000	37.74	-77.15	-	-
4/28/2008	2:55 PM	Gloucester, Mathews	0	0	0	50	11	$20,000	37.39	-76.59	37.47	-76.41
4/28/2008	2:45 PM	Mathews	1	0	0	50	0.3	$50,000	37.39	-76.37	37.39	-76.36
5/31/2008	2:52 PM	King William	0	0	0	50	1	$50,000	37.77	-77.27	37.78	-77.25
4/16/2011	4:45 PM	Gloucester, Mathews	3	2	24	800	46.89	$8,020,000	37.1532	-76.704	37.4636	-76.4241
4/16/2011	4:30 PM	Middlesex	1	0	0	400	1.06	$100,000	37.6743	-76.6037	37.681	-76.5862
4/16/2011	5:25 PM	Middlesex	2	0	0	400	2.8	$6,000,000	37.5331	-76.3528	37.5693	-76.3299
2/24/2012	5:25 PM	Mathews	0	0	0	50	0.75	$20,000	37.3337	-76.3012	37.3356	-76.2878
5/22/2014	4:05 PM	King and Queen	0	0	0	50	0.85	$0.01	37.78	-76.94	37.7709	-76.9297

Section 5: Risk Assessment Analysis – Flooding, Hurricane, and Sea Level Rise

Hazus is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of Hazus is to provide methodology and software application to develop multi-hazard losses at a regional scale. The loss estimates are used primarily by local, state and regional officials to plan and stimulate efforts to reduce risk from multi-hazards and prepare for emergency response and recovery[1].

Potential loss estimates analyzed in Hazus-MH include:

- Physical damage to residential and commercial buildings, schools, essential facilities, and infrastructure
- Economic loss including lost jobs, business interruptions, repair and reconstruction costs.

The Hazus Flood Model analyzes both riverine and coastal flood hazards. Flood hazard is defined by a relationship between depth of flooding and the annual chance of inundation to that depth. Statistical flood frequencies were modeled in this revision to be able to determine annualized loss for each of the counties in Middle Peninsula PDC. Statistical flood frequencies are modeled by looking at the damage that is likely to occur over a given period of time, known as a return period or recurrence interval.

Depth, duration and velocity of water in the floodplain are the primary factors contributing to flood losses. Other hazards associated with flooding that contribute to flood losses include channel erosion and migration, sediment deposition, bridge scour and the impact of flood-born debris. The Hazus Flood Model allows users to estimate flood losses primarily due to flood depth to the general building stock (GBS). While velocity is also considered, it is not a separate input parameter and is accounted within depth-damage functions (i.e., expected percent damage given an expected depth) for census blocks that are defined as either coastal or riverine influenced. The agricultural component will allow the user to estimate a range of losses to account for flood duration. The flood model does not estimate the losses due to high velocity flash floods at this time[1].

Flood Analysis

The flood analysis for the HIRA was completed using the FEMA Hazus – MH V2.2 software for both riverine and coastal flood hazards. Varying flood analyses have been performed to both identify and characterize the flood hazard and the subsequent loss-potential or risk. The standard methodology of defining loss potential for any given hazard, includes annualizing the potential over a series of statistical return periods. Annualization is the mathematical method of converting individual losses to a weighted-average that may be experienced in any given year. The standard scope pertaining to flood risk corresponds to annualizing the 0.2%, 1%, 2%, 4%, and 10% flooding return periods. In layman's-terms these same annual-chance return periods are often described as the 500-year, 100-year, 50-year, 25-year and 10-year events as shown in Table XX below:

[1] HAZUS-MH Flood User Manual

Table XX. Annual probability base on flood recurrence intervals.

Flood Recurrence Interval	Annual Chance of Occurrence
10 year	10.0%
25 year	4.0%
50 year	2.0%
100 year	1.0%
500 year	0.2%

Practically, these statistical events represent the chance of being equaled or exceeded in any given year; i.e., the likelihood that a particular event with a given intensity occurs on average at least once every x-years. Once each of these statistical return periods are calculated, an annualized value is computed thus offering a perspective for any given year.

The various flood modeling performed as part of the current Plan update, along with the respective risk results, represent the primary goal of producing estimated flood losses for the aforementioned statistical return periods and then the annualized flood losses. However, it is important to note that the idiom of 'comparing apples with oranges' very-much applies to the various elements of flood modeling as well as modeling risk from flooding potential. Therefore, where appropriate differing modeling methodologies and their respective results have been separated for comparative purposes as described and highlighted in the bulleted List below. The same list also presents the order in which Hazus modeling information is presented:

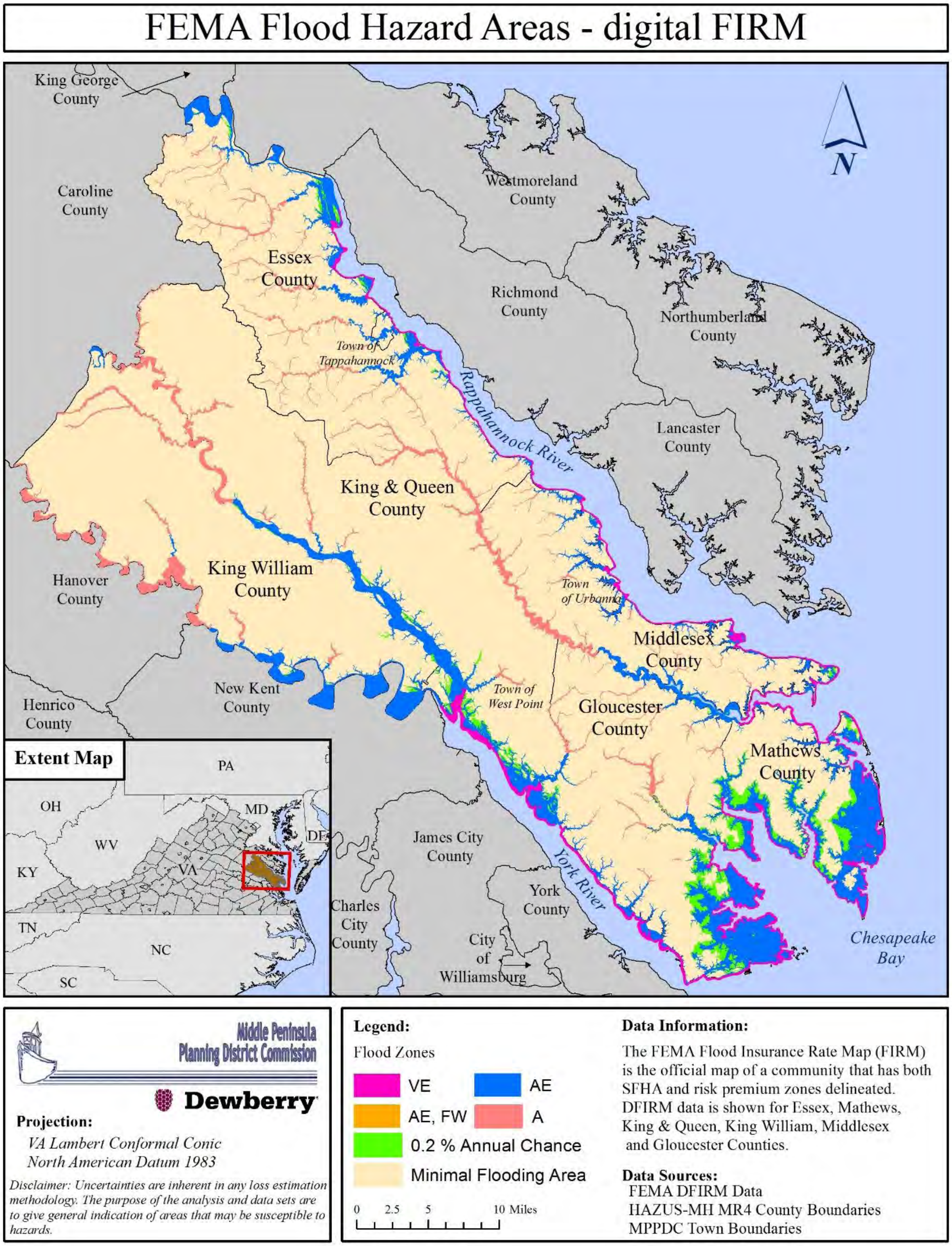
The various modeling performed includes the following:

- **FEMA Floodplains and Depth Grid Information**
- **Hazus Building Stock (Inventory of Buildings)**:
    - All modeling utilized stock Hazus inventory values (Version 2.2 – Census 2010)
    - All modeling utilized Hazus Dasymetric Census Geographies
    - All modeling utilized stock Hazus facilities
- **Hazus Level I Multi-frequency Flood Modeling** – Hazus Level I methodology employed
    - Core Inputs or Parameters:
        - Digital Elevation Model (DEM) – National Elevation Dataset (NED) One-Arc Second (~30 meter resolution)
        - Frequencies (Both Riverine & Coastal) - 0.2%, 1%, 2%, 4%, and 10%
        - Riverine:
            - One-Square Mile (1 mi^2)Drainage Threshold
        - Coastal:
            - Stillwater elevations from Table 2 – Transect Data from each respective FEMA Flood Insurance Study (FIS):
                - ESSEX COUNTY – Revised May 4, 2015
                - GLOUCESTER COUNTY – Revised November 19, 2014
                - KING AND QUEEN COUNTY – Preliminary October 3, 2013
                - KING WILLIAM COUNTY – Preliminary October 3, 2013

        - MIDDLESEX COUNTY – Revised May 18, 2015
        - MATHEWS COUNTY – Revised December 9, 2014
    - NOTE: Hazus stock shoreline data was modified to extend up the York River so that Level 1 coastal modeling could be completed for King William County, King and Queen County and portions of Gloucester County upstream of the George Washington Memorial Highway Bridge (US 17).
- **Hazus Level 1 Annualized Loss** - Hazus Level 1 methodology employed (from Multi-frequency above)
- **Comparative Flood Modeling**:
    - FEMA RiskMAP 1% Coastal - Hazus Level 2 methodology employed
        - Hazus Level 2 – Only use of the updated or refined flood hazard produced and provided by Army Corps of Engineers (USACE) for FEMA Risk MAP studies
    - Hazus Level 1 – Only 1% Coastal (from Multi-frequency above)
        - Use only the Level 1 Coastal 1% frequency to compare to the FEMA RiskMAP Coastal 1% frequency

FEMA Floodplains and Depth Grid Information

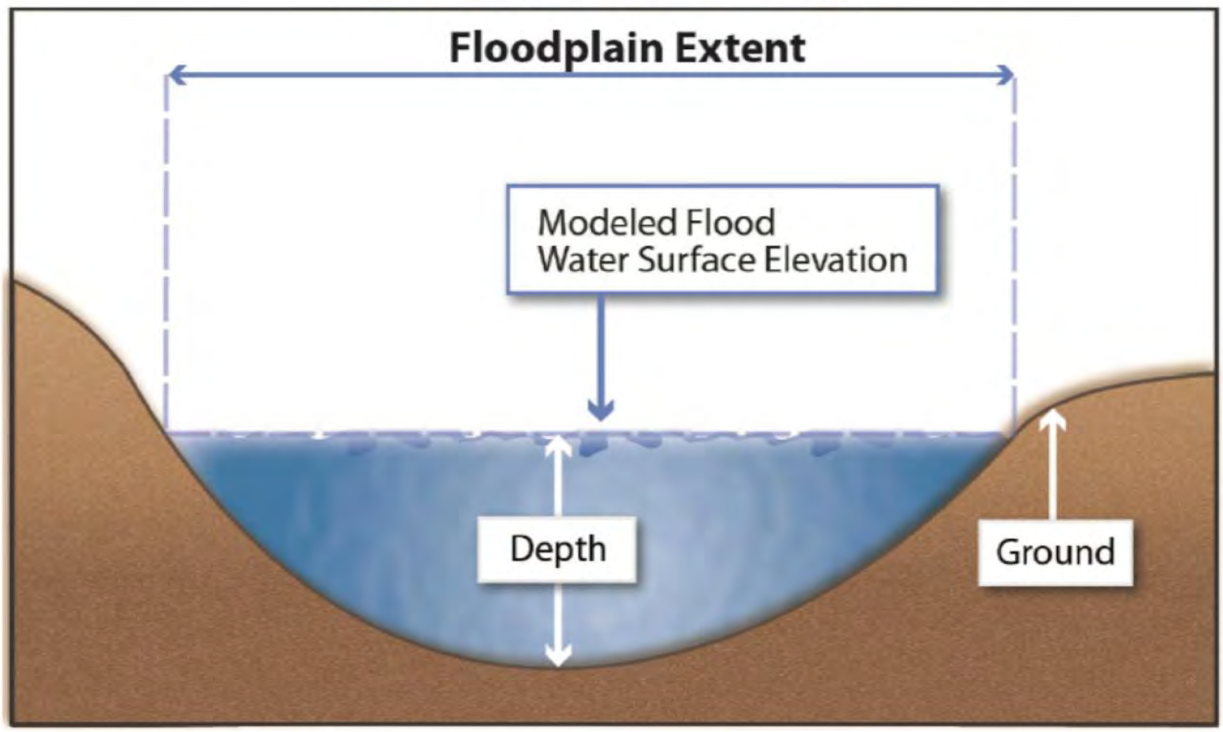
FEMA initiates Flood Insurance Studies (FIS) on a national prioritization schedule. The most recent FIS's have been incorporated into this Plan as outlined by date in the list above; dates ranging from October 2013 to May 2015. These various new studies have produced updated coastal flood hazards for all of the jurisdictions in the MPPDC planning area; and riverine flood hazards remain from previous flood insurance studies. Figure XX illustrates the extent of flood hazards as defined by the most recent FEMA flood insurance studies.


FEMA Flood Hazard Areas - digital FIRM
King George County
Caroline County
Essex County
Westmoreland County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Town of West Point
Gloucester County
Henrico County
Mathews County
James City County
York River
Charles City County
York County
City of Williamsburg
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Flood Zones
VE
AE
AE, FW
A
0.2 % Annual Chance
Minimal Flooding Area
0 2.5 5 10 Miles
Data Information:
The FEMA Flood Insurance Rate Map (FIRM) is the official map of a community that has both SFHA and risk premium zones delineated. DFIRM data is shown for Essex, Mathews, King & Queen, King William, Middlesex and Gloucester Counties.
Data Sources:
FEMA DFIRM Data
HAZUS-MH MR4 County Boundaries
MPPDC Town Boundaries

The new coastal flood hazards associated with the most recent FEMA studies have been produced under the RiskMAP Program. In short, the RiskMAP Program seeks to include risk assessments as part of a flood insurance study to better communicate the risk of flooding. Consequently, a RiskMAP study includes all of the regulatory Flood Insurance Study products; namely engineering, floodplain mapping, digital FIRM data and report text. However, in addition to the traditional regulatory products, RiskMAP also includes new non-regulatory products aimed at communicating risk. One of the core non-regulatory datasets includes the creation of depth grids from the digital FIRM data. These new depth grids are the key to performing risk assessments in the Hazus software as they are able to be directly imported.

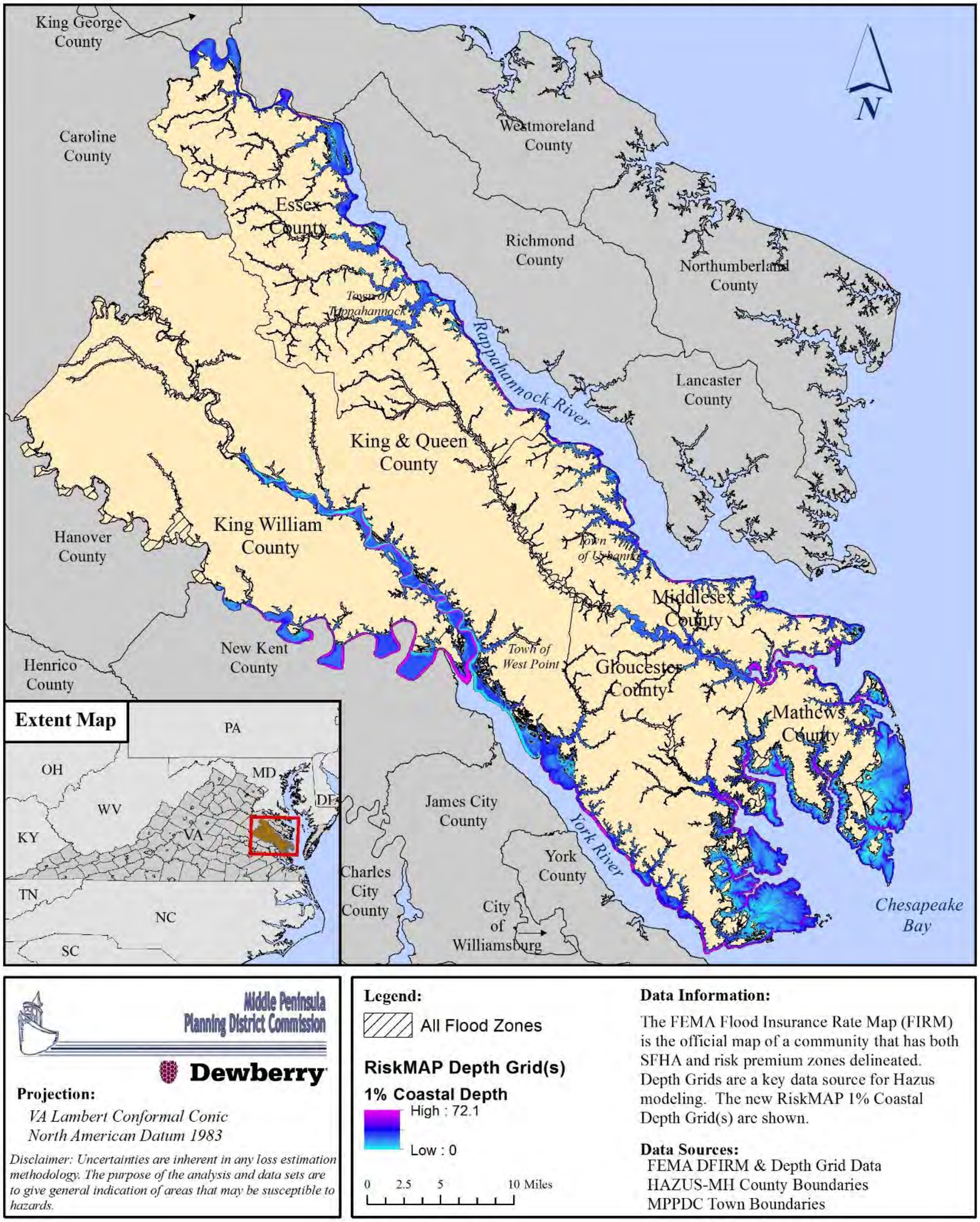
The flood hazard within Hazus is ultimately defined by a depth grid which is a representation of the difference between the estimated water surface and ground elevations for each respective flood frequency or annual chance. The following image is a simplified representation as shown in FEMA's Guidance for Flood Risk Analysis and Mapping, Flood Depth and Analysis Grids (May 2014):

Figure 7: Depth Grid in Cross Section View



The new RiskMAP projects for each of the counties in the MPPDC planning area include new coastal 1% Annual Chance depth grids. Figure XX below shows these new coastal 1% Annual Chance depth grids and the new FEMA digital FIRM floodplains:

FEMA digital FIRM & RiskMAP 1% Coastal Depth Grid



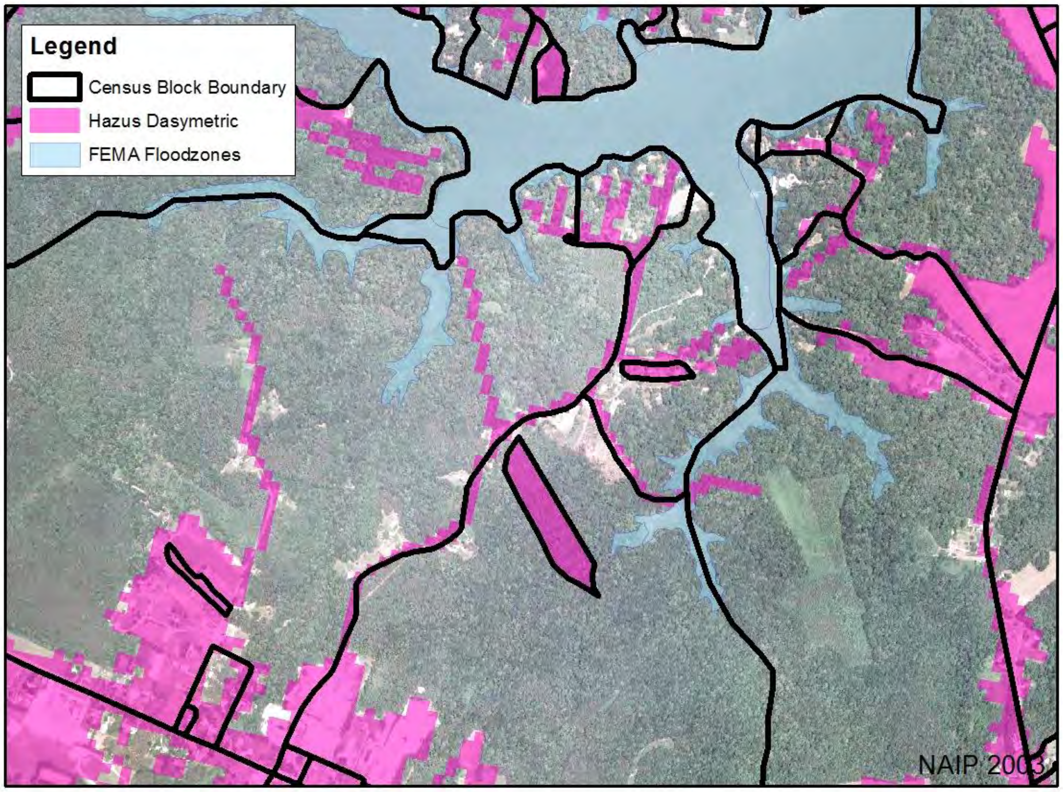
RiskMAP depth grids are considered to be superior to depth grids created from typical out-of-the-box Hazus analyses for a variety of reasons. However, users should understand that RiskMAP coastal projects are only scoped to produce 1% Annual Chance depth grids; i.e., multi-frequency depth grids are not prescribed for coastal projects. Armed with this information, it therefore becomes necessary to model multiple-frequencies in Hazus to arrive at annualized loss results. Fortunately, Hazus is a tool that offers flexibility and enables the user to provide more detailed inputs or specify input parameters that can introduce an increased level of reliability of depth values produced. Notwithstanding, RiskMAP depth grids are considered superior because of the guidelines under which they were created and the precision and accuracy of the inputs to their creation. Ultimately, where RiskMAP projects produce new multi-frequency depth grids, these grids can all be run through Hazus and a new annualized values can be produced. And where multi-frequency depth grids do not exist, it best to refrain from 'mixing apples and oranges' and rather, compare results for relative differences or similarities.

Ultimately, the Hazus flood modeling and risk assessments for this Plan update have been produced with the intent to improve upon previous Plan Hazus modeling and to incorporate any new RiskMAP-based depth grids. Riverine flood hazards were not updated in the most recent FIS's and there are no new RiskMAP depth grids. Therefore, this Plan update includes Hazus Level 1 multi-frequency modeling for both riverine and coastal. Improvements to the riverine modeling from the previous Plan are related to the drainage area threshold defined. In most cases, the FEMA flood maps have been developed for streams with contributing drainage area of 1 square mile. The previous Plan Hazus flood modeling only utilized a one-square mile drainage threshold for Mathews County and the remainder were completed at ten-square mile. However, this Plan revision has utilized one-square mile drainage threshold for all counties in the MPPDC region. As for the Level 1 multi-frequency modeling for coastal influences, the new Stillwater elevations from Table 2 – Transect Data from each respective FEMA Flood Insurance Study (FIS) was entered into the Hazus software.

Results from the various Hazus flood modeling are covered in sections below with primary focus on the annualized results. However, first the inventory of building stock is discussed.

Building Stock

Hazus building stock is the inventory of buildings (i.e., square-footage) of each respective type or sub-type of buildings in the following categories; residential, commercial, industrial, agricultural, religious, government, and education. Hazus assumes that all square-footage (i.e., buildings) are evenly distributed throughout a given census block and therefore damage is estimated as a percent and is weighted by the area of inundation at a given depth for a given census block. The methodology therefore, is known as an area-weighted methodology. FEMA has initiated recent improvements to the area-weighted methodology by further refining the distribution of building square-footage to land areas characterized by development and removing land areas typical of non-developed land classes (e.g., forests, wetlands, etc…). This refinement is called dasymetric mapping and the current Plan modeling utilizes the FEMA dasymetric building stock. The following shows a small example area in which the developed areas are pink:



Use of the new dasymetric data will typically reduce the total area subject to area-weighted loss estimations - particularly for those census blocks that have flood risk yet actual development does not exist within the floodplains. An area analysis of the dasymetric versus full stock census blocks is exemplified in the chart below:

Digital FIRM Acreage Type	Census Block Type	
	Dasymetric	Full Stock
Acres of 0.2% Annual Chance Floodplains (500-year)	5,909 Ac (1% of Total Acres)	14,806 Ac (2% of Total Acres)
Acres of 1% Annual Chance Floodplains (100-year)	23,216 Ac (3% of Total Acres)	85,736 Ac (11% of Total Acres)
Total Acres of Census Blocks MPPDC Region		**794,644 Ac**

A comparison of FEMA digital FIRM data intersecting the two types of Hazus census blocks reveals that an estimated four-percent (4%) of the dasymetric data is within the extents of the 0.2% Annual Chance Floodplains versus thirteen-percent (13%) when using full census blocks. And, considering the 1% Annual Chance Floodplains, there is approximately three-percent (3%) intersecting the dasymetric data versus eleven-percent (11%) when using full census blocks. Consequently, this refinement can be considered a benefit to the risk analyses in that the expectation of over-estimations are mitigated by limiting potential losses ONLY to developed areas.

As noted earlier, loss estimations are first based on inundation area for specified sub-types of building square-footage. The second type of data includes information on the local economy that is used in estimating losses. Table XX displays the economic loss categories used to calculate annualized losses by Hazus. Data for this analysis has been provided at the census block level.

Table XX. Hazus direct economic loss categories and descriptions.

Category Name	Description of Data Input into Model	Hazus Output
Building	Cost per sq ft to repair damage by structural type and occupancy for each level of damage	Cost of building repair or replacement of damaged and destroyed buildings
Contents	Replacement value by occupancy	Cost of damage to building contents
Inventory	Annual gross sales in $ per sq ft	Loss of building inventory as contents related to business activities
Relocation	Multiple factors; primarily a function of Rental Costs ($/ft^2/month) for non-entertainment buildings where damage ≥10%	Relocation expenses (for businesses and institutions); disruption costs to building owners for temporary space.
Income	Income in $ per sq ft per month by occupancy	Capital-related incomes losses as a measure of the loss of productivity, services, or sales
Rental	Rental costs per month per sq ft by occupancy	Loss of rental income to building owners
Wage	Wages in $ per sq ft per month by occupancy	Employee wage loss as described in income loss

Middle Peninsula currently has approximately 43,501 structures with an estimated exposure value of approximately $17.7 billion. Average estimated replacement value of buildings in the study area range from approximately $94,000 to $297,000, with the mean approximation value of $134,000 [2]. Eighty-one percent of the planning district's general occupancy is categorized as residential, followed by commercial (12%). Table XX below provides inventory information for each of the six counties that were included in the analysis. Gloucester County occupies a large percentage (40%) of the building stock exposure for the region.

Table XX. Building stock exposure for general occupancies by county.

County	Residential	Commercial	Industrial	Agriculture	Religion	Govt.	Education	Total
Gloucester	$5,698,054	$831,318	$147,429	$32,557	$84,190	$32,437	$190,065	$7,016,050
King William	$2,463,239	$274,254	$110,725	$32,549	$41,687	$24,273	$24,786	$2,971,513
Middlesex	$2,151,683	$354,607	$65,244	$14,045	$26,670	$11,736	$40,679	$2,664,664
Essex	$1,578,275	$402,650	$146,178	$25,395	$28,679	$18,661	$31,423	$2,231,261
Mathews	$1,566,770	$149,340	$45,066	$9,877	$19,875	$6,830	$12,042	$1,809,800
King & Queen	$886,914	$52,850	$29,064	$6,710	$19,927	$2,968	$7,284	$1,005,717
Total	$14,344,935	$2,065,019	$543,706	$121,133	$221,028	$96,905	$306,279	$17,699,005
All values are in thousands of dollars								

[2] Previous Plan values adjusted per BLS CPI Inflation Calculator (2000 to 2010) to match Hazus/Census years.

Building stock exposure is also classified by building type. General Building Types (GBTs) have been developed as a means to classify the different buildings types. This provides an ability to differentiate between buildings with substantially different damage and loss characteristics. Model building types represent the characteristics of core construction of buildings in a class. The damage and loss prediction models are developed for model building types and the estimated performance is based upon the "average characteristics" of the total population of buildings within each class. Five general classifications have been established, including wood, masonry, concrete, steel and manufactured homes (MH). A brief description of the building types is available in Table XX. The Hazus inventory serves as the default when a user does not have better data available.

Table XX. Hazus General Building Type classes.

General Building Type	Description
Wood	Wood frame construction
Masonry	Reinforced or unreinforced masonry construction
Steel	Steel frame construction
Concrete	Cast-in-place or pre-cast reinforced concrete construction
MH	Factory-built residential construction

Wood construction represents the majority (61%) of building types in the planning district. Masonry construction accounts for a quarter of the building type exposure. Table XX below provides building stock exposure for the five main building types.

Table XX. Building stock exposure for general building type by county.

County	Wood	Masonry	Concrete	Steel	Manufactured Home	Total
Gloucester	$4,338,118	$1,782,044	$177,833	$591,235	$126,913	$7,016,143
King William	$1,895,656	$751,978	$61,374	$227,445	$35,155	$2,971,608
Middlesex	$1,631,388	$678,395	$67,789	$225,948	$61,315	$2,664,835
Mathews	$1,166,398	$450,836	$32,534	$113,035	$47,165	$1,809,968
Essex	$1,202,922	$558,827	$102,763	$319,225	$47,615	$2,231,352
King & Queen	$661,413	$247,318	$11,118	$49,521	$36,527	$1,005,897
Total	$10,895,895	$4,469,398	$453,411	$1,526,409	$354,690	$17,699,803
All values are in thousands of dollars						

Multi-frequency Flood Modeling – Hazus Level 1 methodology

As explained earlier, annualized loss is the preferred manner with which to express potential risk for hazard mitigation planning as it is useful for creating a common denominator by which different types of hazards can be compared. The tables below (Table XX – Table XX) show the multi-frequency results for the MPPDC Region and each County. The following section will present details of the annualized losses; see General Building Stock Loss Estimation (Annualized Flood Loss).

Table XX. Hazus Level I Multi-frequency GBS Losses for the MPPDC Region.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
MPPDC Region	Level I - 10YR	$107,113	$57,802	$48,644	$1,126
MPPDC Region	Level I - 25YR	$137,228	$74,580	$61,788	$1,375
MPPDC Region	Level I - 50YR	$194,731	$105,823	$87,602	$1,941
MPPDC Region	Level I - 100YR	$245,562	$133,342	$110,570	$2,427
MPPDC Region	Level I - 500YR	$842,030	$460,912	$375,607	$7,497
MPPDC Region	Level I - Annualized	$18,102	$9,921	$8,111	$116
		Data in Thousands of Dollars			

Table XX. Hazus Level I Multi-frequency GBS Losses for Essex County.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Essex County	Level I - 10YR	$7,226	$3,729	$3,432	$80
Essex County	Level I - 25YR	$8,994	$4,676	$4,243	$89
Essex County	Level I - 50YR	$12,846	$6,599	$6,126	$140
Essex County	Level I - 100YR	$16,813	$8,843	$7,846	$144
Essex County	Level I - 500YR	$31,230	$16,306	$14,666	$287
Essex County	Level I - Annualized	$1,047	$548	$493	$6
Data in Thousands of Dollars					

Table XX. Hazus Level I Multi-frequency GBS Losses for Gloucester County.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Gloucester County	Level I - 10YR	$53,037	$27,925	$24,750	$25,491
Gloucester County	Level I - 25YR	$68,606	$36,345	$31,788	$32,684
Gloucester County	Level I - 50YR	$98,481	$52,381	$45,397	$46,610
Gloucester County	Level I - 100YR	$121,998	$64,526	$56,568	$58,085
Gloucester County	Level I - 500YR	$565,571	$310,999	$251,301	$255,854
Gloucester County	Level I - Annualized	$9,984	$5,394	$4,552	$79
Data in Thousands of Dollars					

Table XX. Hazus Level 1 Multi-frequency GBS Losses for King and Queen County.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
King and Queen County	Level 1 - 10YR	$3,850	$2,295	$1,512	$43
King and Queen County	Level 1 - 25YR	$5,152	$3,088	$2,011	$53
King and Queen County	Level 1 - 50YR	$7,086	$4,294	$2,735	$57
King and Queen County	Level 1 - 100YR	$7,535	$4,612	$2,878	$45
King and Queen County	Level 1 - 500YR	$19,376	$11,714	$7,506	$156
King and Queen County	Level 1 - Annualized	$585	$355	$224	$6
Data in Thousands of Dollars					

Table XX. Hazus Level 1 Multi-frequency GBS Losses for King William County.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
King William County	Level 1 - 10YR	$12,037	$5,882	$6,084	$107
King William County	Level 1 - 25YR	$14,339	$7,084	$7,169	$124
King William County	Level 1 - 50YR	$17,689	$8,729	$8,851	$147
King William County	Level 1 - 100YR	$20,858	$10,332	$10,395	$191
King William County	Level 1 - 500YR	$65,545	$29,037	$35,462	$1,584
King William County	Level 1 - Annualized	$1,656	$797	$852	$11
Data in Thousands of Dollars					

Table XX. Hazus Level 1 Multi-frequency GBS Losses for Mathews County.

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Mathews County	Level 1 - 10YR	$21,094	$12,426	$8,575	$104
Mathews County	Level 1 - 25YR	$29,509	$17,341	$12,025	$167
Mathews County	Level 1 - 50YR	$45,778	$26,496	$19,003	$325
Mathews County	Level 1 - 100YR	$60,800	$35,055	$25,356	$451
Mathews County	Level 1 - 500YR	$134,862	$78,353	$55,815	$798
Mathews County	Level 1 - Annualized	$3,682	$2,170	$1,500	$13
Data in Thousands of Dollars					

Table XX. Hazus Level 1 Multi-frequency GBS Losses for Middlesex County

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Middlesex County	Level 1 - 10YR	$9,869	$5,545	$4,291	$51
Middlesex County	Level 1 - 25YR	$10,628	$6,046	$4,552	$46
Middlesex County	Level 1 - 50YR	$12,851	$7,324	$5,490	$59
Middlesex County	Level 1 - 100YR	$17,558	$9,974	$7,527	$79
Middlesex County	Level 1 - 500YR	$25,446	$14,503	$10,857	$119
Middlesex County	Level 1 - Annualized	$1,148	$657	$490	$1
Data in Thousands of Dollars					

General Building Stock Loss Estimation (Annualized Flood Loss)

Annualized loss is the preferred manner with which to express potential risk for hazard mitigation planning as it is useful for creating a common denominator by which different types of hazards can be compared. While annualized loss values in and of themselves do not necessarily determine if the values are too high or too low, when compared across a region the relative difference in values can indicate problem areas for prioritization or justification for further and more detailed analyses. Next, we consider the annualized losses of the Hazus Level 1 analyses.

Hazus Level 1 flood model annualized losses for the Middle Peninsula PDC are $18,102,000 US Dollars. Property or "capital stock" losses are $18,093,000 US Dollars and make up about 99.95% of the damages which includes the values for building, content, and inventory. Business interruption accounts for $9,000 US Dollars (0.05%) of the annualized losses and includes relocation, income, rental and wage costs.

The flood model incorporates National Flood Insurance Program (NFIP) entry dates to distinguish Pre-FIRM and Post-FIRM census blocks. The results provided in this report show the combined total losses for both pre- and post-FIRM values combined.

Table XX illustrates the expected annualized losses broken down by county and Table XX includes the annualized losses along with Population and Per-Capita losses.

Table XX. County based Hazus annualized loss for both Pre- and Post-FIRM by building type.

County	Building	Content	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Gloucester	$5,394	$4,552	$31	$0	$1	$0	$6	$9,984
Mathews	$2,170	$1,500	$12	$0	$0	$0	$0	$3,682
King William	$797	$852	$5	$0	$0	$0	$2	$1,656
Middlesex	$657	$490	$1	$0	$0	$0	$0	$1,148
King & Queen	$355	$224	$6	$0	$0	$0	$0	$585
Essex	$548	$493	$6	$0	$0	$0	$0	$1,047
Total	$9,921	$8,111	$61	$0	$1	$0	$8	$18,102
All values in Thousands of Dollars								

Table XX. County based Census 2010 population, Hazus Annualized Loss & Per-Capita Loss.

County	Population[1]	Annualized Loss (US Dollar)	Per-Capita Loss (US Dollar)
Mathews	8,978	$3,682,000	$410.11
Gloucester	36,858	$9,984,000	$270.88
Middlesex	10,959	$1,148,000	$104.75
King William	15,935	$1,656,000	$103.92
Essex	11,151	$1,047,000	$93.89
King and Queen	6,945	$585,000	$84.23
MPPDC Region	**90,826**	**$18,102,000**	**$199.30**
[1] *2010 Census-based population counts - as exists within Hazus stock data.*			

Gloucester County has the highest annualized loss, $9,984,000 US Dollars, accounting for 55.2% of the total losses for Middle Peninsula and 40% of the county's building stock, and ranks second (2nd) in terms of per-capita losses at $270.88. The majority of the expected damages can be attributed to building and content value.

Mathews County has the second highest loss, $3,682,000 US Dollars, accounting for 20.34% of the total annualized losses for Middle Peninsula and 17% of the county's building stock, however has the greatest annualized per-capita loss at $410.11.

Building value loss accounts for approximately 55% of the expected annualized damages and 45% is attributed to content value loss. Table XX summarizes the property losses and business interruption losses shown for pre- and post-FIRM structures.

Residential building damage represents the majority of the damages, followed closely by the residential content damages. Wood buildings account for $11,529,000 US Dollars, or 62.1% of the annualized damages of which the majority (54.06%) are in Gloucester County. Occupancy results indicate that agricultural, non-profit and industrial have the largest percent of exposure at risk; i.e. these are the predominant occupancy types that intersect the flood hazard. Manufactured homes only account for 5.05% of the total annualized damages but have the highest percentage of building stock at risk to yearly damages. Tables XX and XX summarize the property losses and business interruption losses shown by occupancy and building type. The slight differences in the annualized losses for building type and occupancy can be attributed to the Hazus classification methodology.

Table XX: Annualized loss by building type.

Building Type	Building	Contents	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Wood	$6,886	$4,641	$2	$0	$0	$0	$0	$11,529
Masonry	$2,459	$2,122	$6	$0	$0	$0	$2	$4,589
Steel	$329	$1,088	$42	$0	$0	$0	$2	$1,461
Manufactured Housing	$444	$147	$0	$0	$0	$0	$0	$591
Concrete	$80	$289	$5	$0	$0	$0	$1	$375
Annualized Loss	$10,198	$8,287	$55	$0	$0	$0	$5	$18,545
% of Ann. Loss	54.99%	44.69%	0.30%	0%	0%	0%	0.03%	*Hazus-MH (V2.2) results*
Values In Thousands of Dollars								

Table XX: Annualized loss by general occupancy type.

Occupancy Type	Building	Contents	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Residential	$9,244	$5,732	$0	$0	$0	$0	$0	$14,976
Commercial	$426	$1,408	$19	$0	$0	$0	$2	$1,855
Industrial	$161	$352	$41	$0	$0	$0	$0	$554
Non-Profit	$36	$207	$0	$0	$0	$0	$0	$243
Agricultural	$8	$71	$1	$0	$0	$0	$0	$80
Education	$44	$321	$0	$0	$1	$0	$4	$370
Government	$2	$20	$0	$0	$0	$0	$2	$24
Annualized Loss	$9,921	$8,111	$61	$0	$1	$0	$8	$18,102
% of Ann. Loss	54.81%	44.81%	0.34%	0%	0.01%	0%	0.04%	*Hazus-MH (V2.2) results*
Values in Thousands of Dollars								

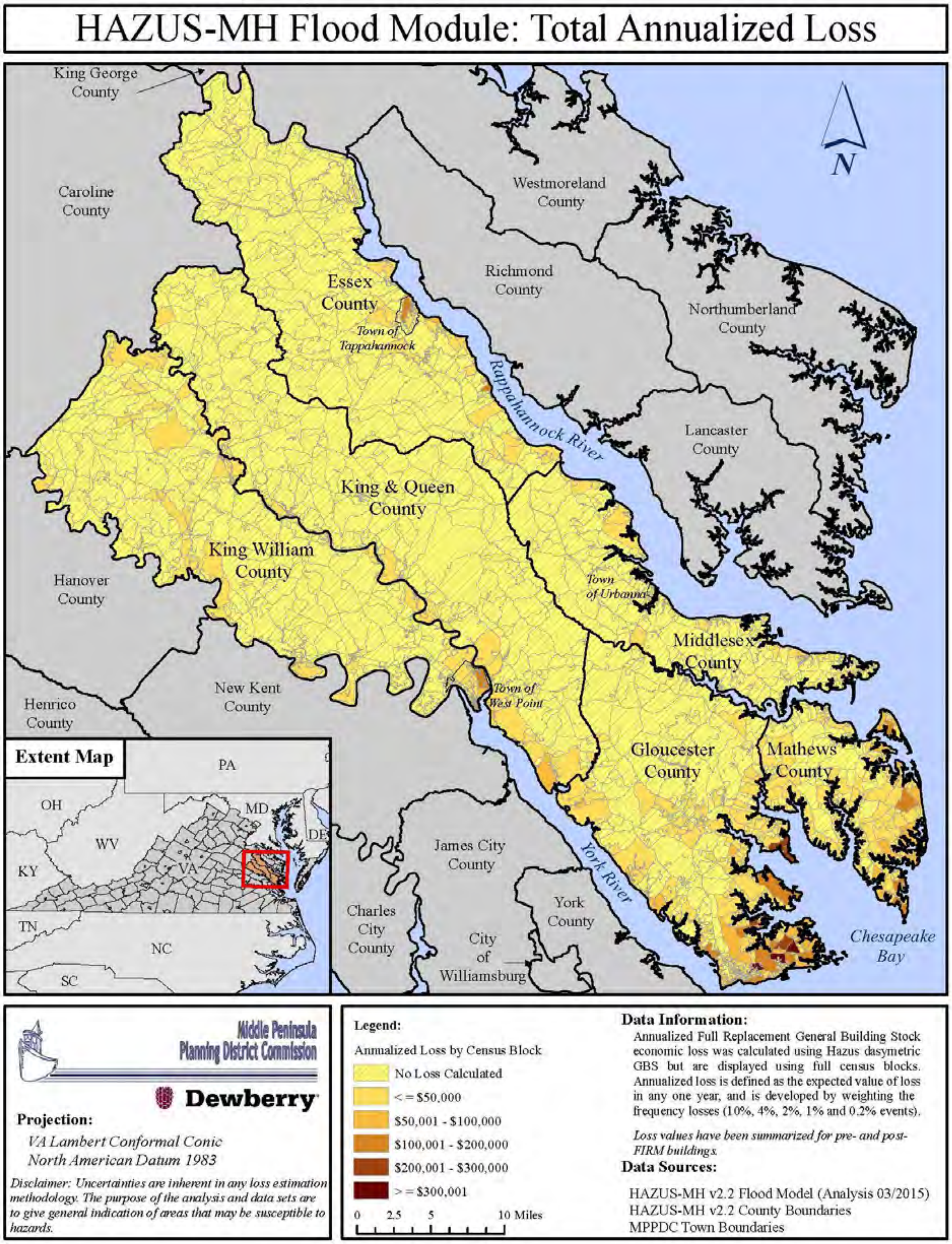
Table XX. County based Hazus annualized loss by general building type.

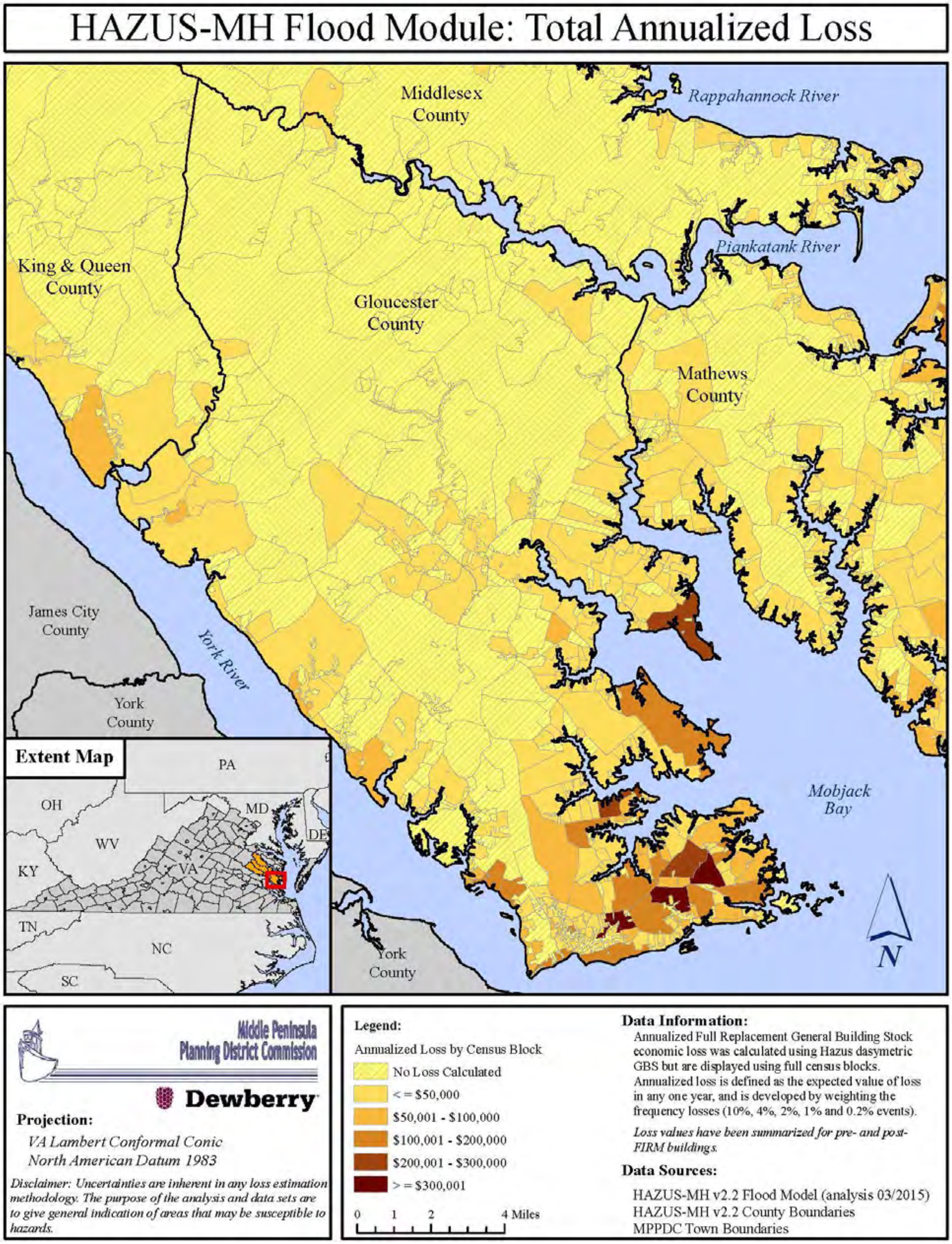
County	Total Exposure	Concrete	Masonry	Manufactured Homes	Steel	Wood	Annualized Loss
Gloucester	$7,016,050	$182	$2,549	$320	$904	$6,233	$10,188
Mathews	$1,809,800	$33	$907	$192	$154	$2,543	$3,829
King William	$2,971,513	$103	$440	$3	$212	$903	$1,661
Middlesex	$2,664,664	$13	$292	$23	$57	$813	$1,198
King & Queen	$1,005,717	$6	$136	$31	$25	$404	$602
Essex	$2,231,261	$38	$265	$22	$109	$633	$1,067
Annualized Loss		$375	$4,589	$591	$1,461	$11,529	$18,545
% of Annualized Loss		2.02%	24.75%	3.19%	7.88%	62.17%	*Hazus-MH (V2.2) results*
% of Total Exposure		2.56%	25.25%	2.00%	8.62%	61.56%	
All values in Thousands of Dollars							

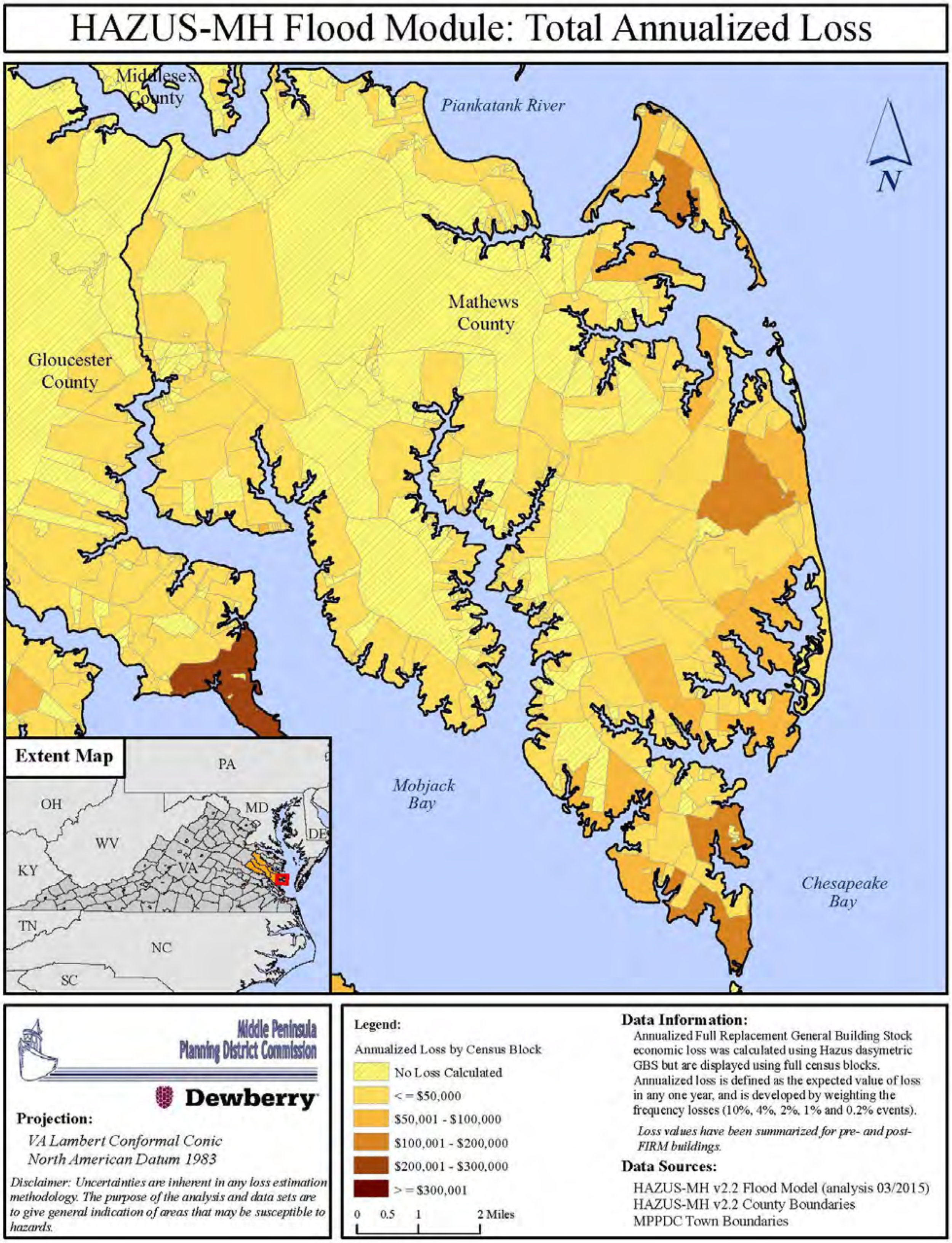
Table XX. County based Hazus annualized loss by general occupancy type.

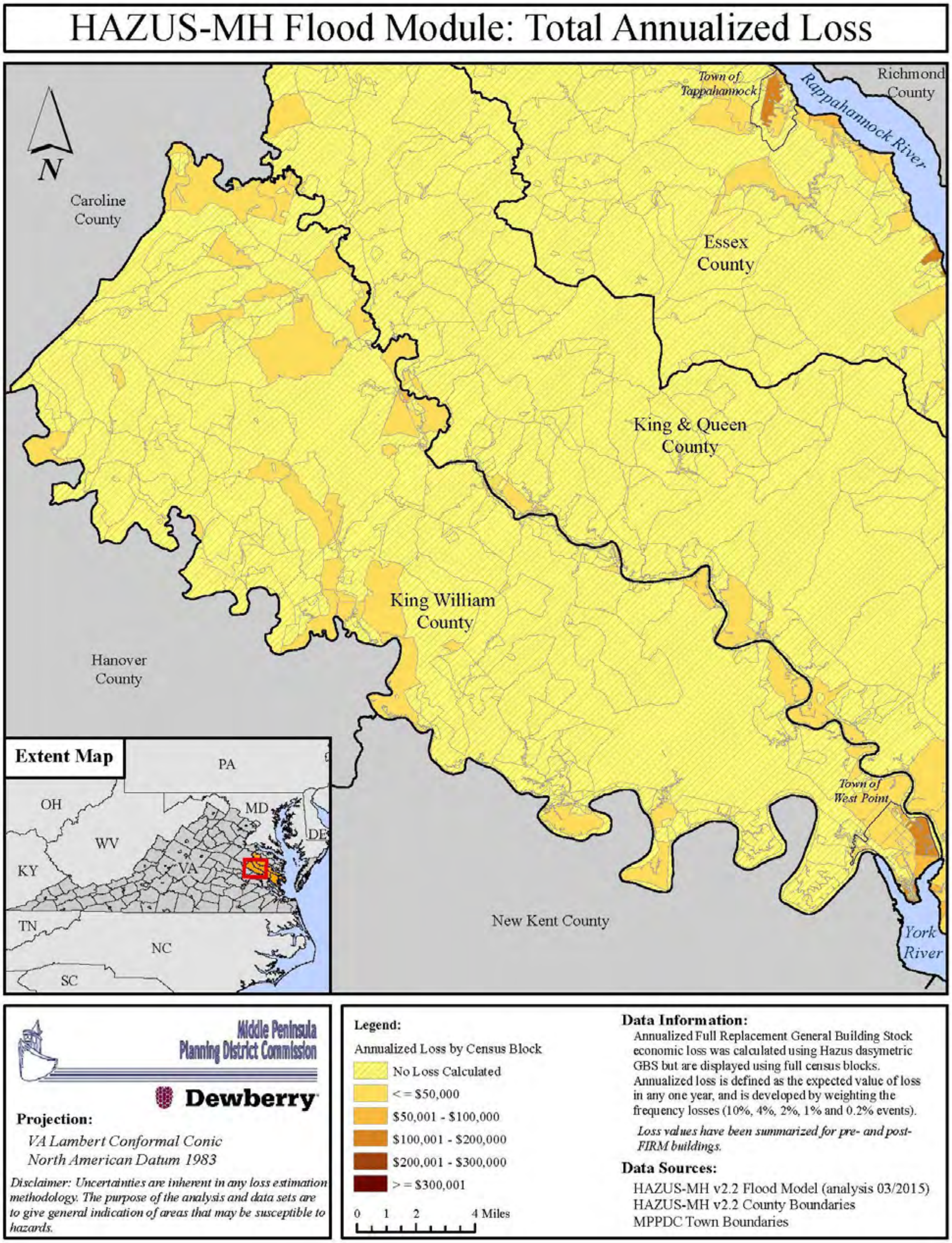
County	Total Exposure	Residen-tial	Comm-ercial	Indust-rial	Non-Profit	Educa-tion	Govern-ment	Agricul-ture	Annualized Loss
Gloucester	$7,016,050	$7,948	$1,227	$249	$153	$354	$8	$45	$9,984
Mathews	$2,231,261	$3,350	$139	$123	$36	$5	$3	$26	$3,682
King William	$2,971,513	$1,285	$243	$65	$39	$6	$12	$6	$1,656
Middlesex	$2,664,664	$1,017	$98	$18	$14	$1	$0	$0	$1,148
King & Queen	$1,005,717	$543	$0	$42	$0	$0	$0	$0	$585
Essex	$1,809,800	$833	$148	$57	$1	$4	$1	$3	$1,047
Annualized Loss		$14,976	$1,855	$554	$243	$370	$24	$80	$18,102
% of Annualized Loss		82.73%	10.25%	3.06%	1.34%	2.04%	0.13%	0.44%	*Hazus-MH (V2.2) results*
% of Exposure		81.05%	11.67%	3.07%	1.25%	1.73%	0.55%	0.68%	

Figures XX through XX on the following pages show the total annualized loss for the planning district and individual counties culminating in Figure XX which categorizes the Total Annualized Losses by Top Ten ranking and a Hotspot overlay representing those areas throughout the MPPDC Region that may require mitigation measures.

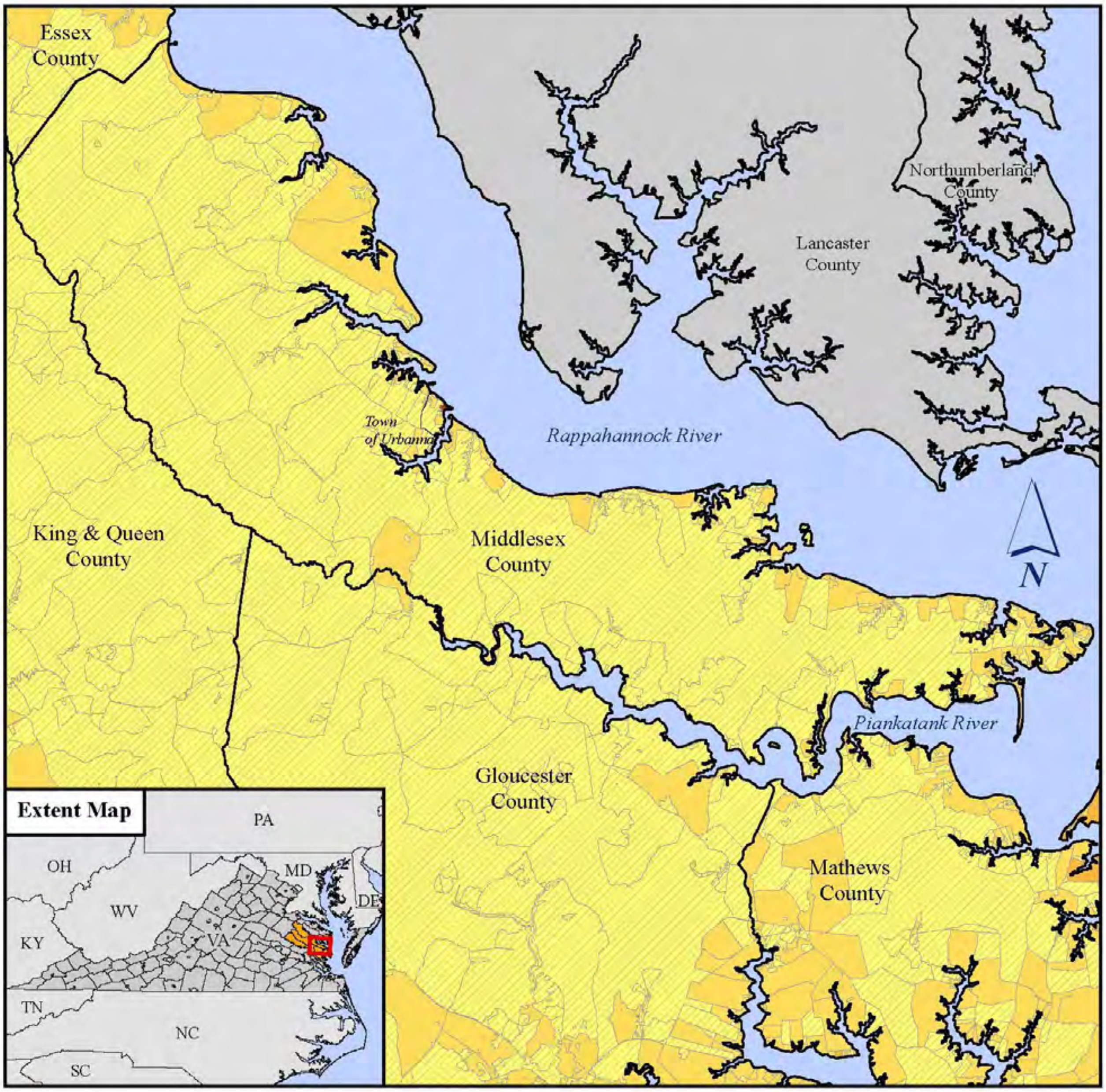

HAZUS-MH Flood Module: Total Annualized Loss
King George County
Caroline County
Westmoreland County
Richmond County
Northumberland County
Essex County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
Henrico County
New Kent County
Town of West Point
Gloucester County
Mathews County
York River
James City County
Charles City County
City of Williamsburg
York County
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 2.5 5 10 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Total Annualized Loss
Middlesex County
Rappahannock River
Piankatank River
King & Queen County
Gloucester County
Mathews County
James City County
York River
York County
Mobjack Bay
Extent Map
PA
OH
MD
DE
WV
VA
KY
TN
NC
SC
York County
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1 2 4 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Total Annualized Loss
Middlesex County
Piankatank River
Mathews County
Gloucester County
Mobjack Bay
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 0.5 1 2 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Total Annualized Loss
N
Town of Tappahannock
Richmond County
Rappahannock River
Caroline County
Essex County
King & Queen County
King William County
Hanover County
Town of West Point
New Kent County
York River
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1 2 4 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

HAZUS-MH Flood Module: Total Annualized Loss



Middle Peninsula Planning District Commission

Dewberry

Projection:

VA Lambert Conformal Conic
North American Datum 1983

Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.

Legend:

Annualized Loss by Census Block

- No Loss Calculated
- < = $50,000
- $50,001 - $100,000
- $100,001 - $200,000
- $200,001 - $300,000
- > = $300,001

0 1 2 4 Miles

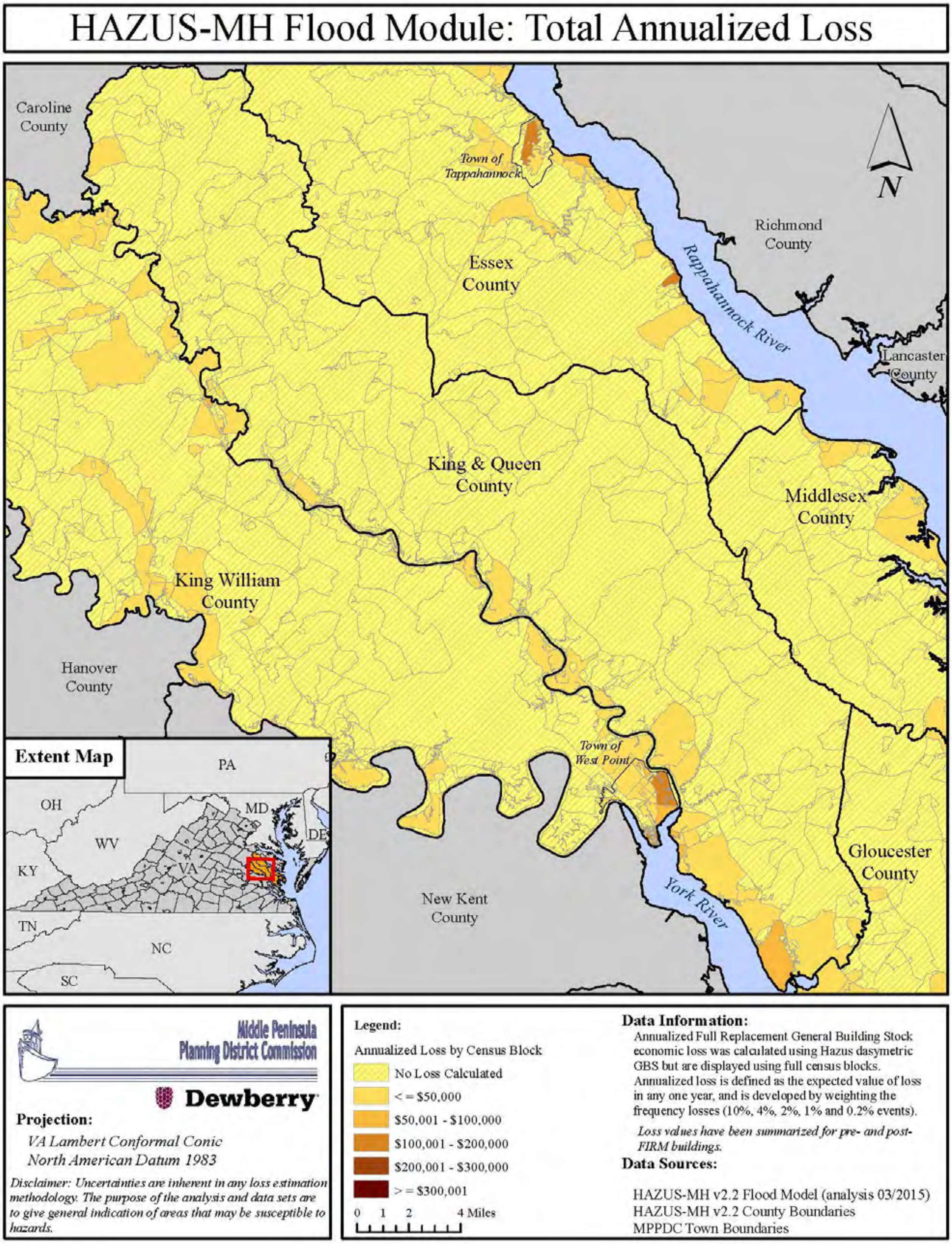
Data Information:

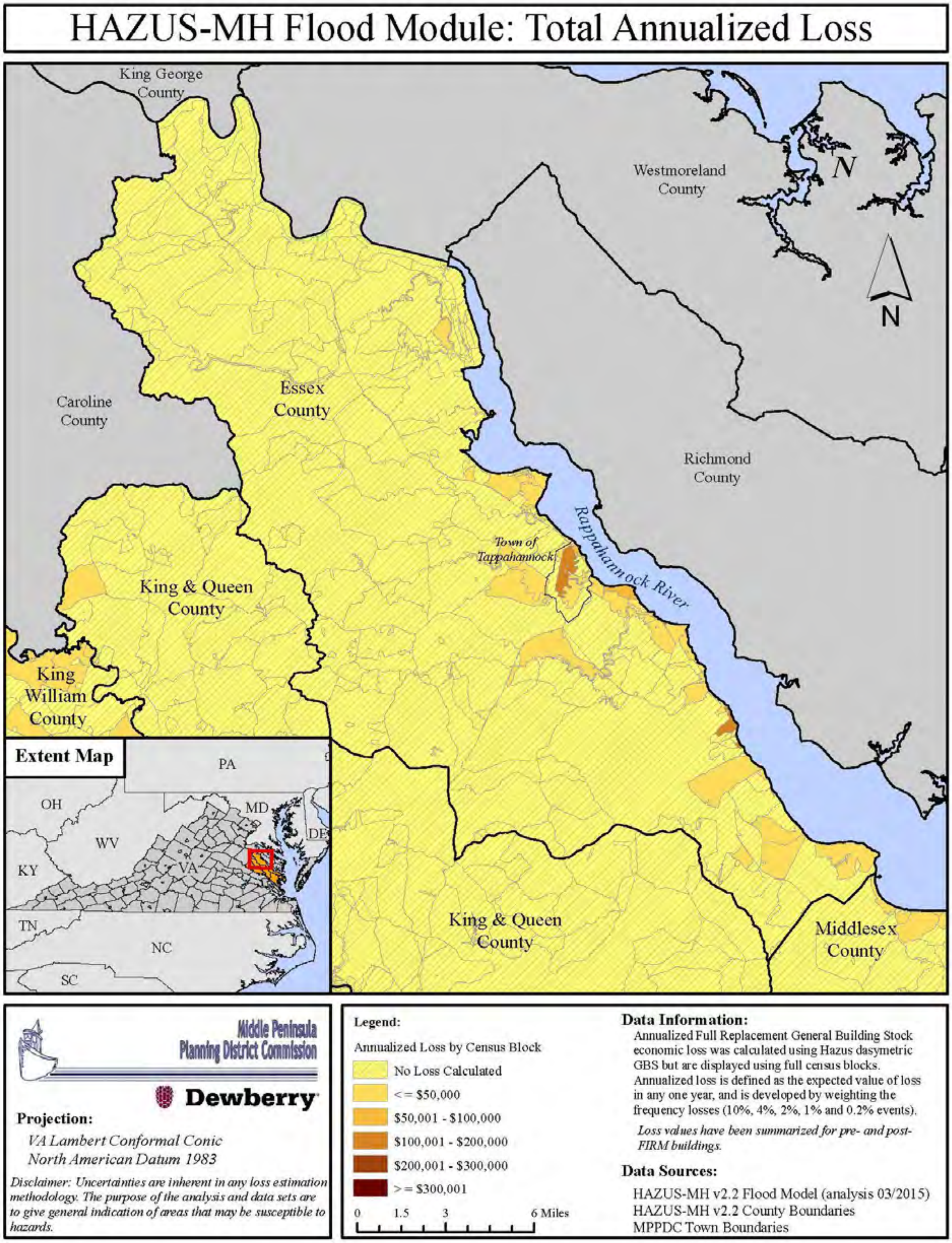
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).

Loss values have been summarized for pre- and post-FIRM buildings.

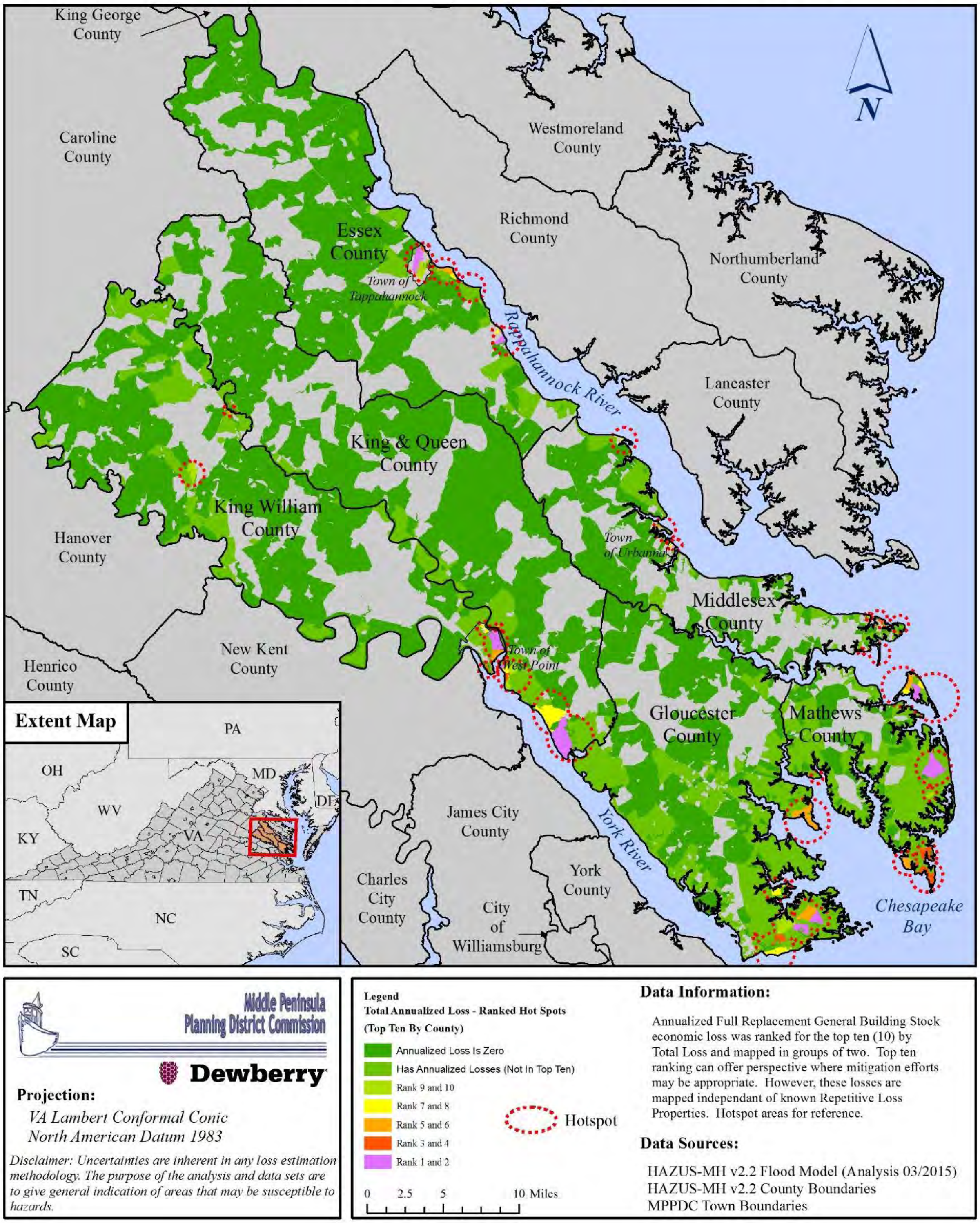
Data Sources:

HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Total Annualized Loss
Caroline County
Town of Tappahannock
Essex County
Richmond County
Rappahannock River
Lancaster County
King & Queen County
Middlesex County
King William County
Hanover County
Town of West Point
Gloucester County
York River
New Kent County
N
Extent Map
PA
OH
MD
DE
WV
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1 2 4 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Total Annualized Loss
King George County
Westmoreland County
Essex County
Caroline County
Richmond County
Town of Tappahannock
Rappahannock River
King & Queen County
King William County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
King & Queen County
Middlesex County
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
No Loss Calculated
<= $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
>= $300,001
0 1.5 3 6 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was calculated using Hazus dasymetric GBS but are displayed using full census blocks. Annualized loss is defined as the expected value of loss in any one year, and is developed by weighting the frequency losses (10%, 4%, 2%, 1% and 0.2% events).
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

HAZUS-MH Flood Module: Total Annualized Loss (Ranked)



Gloucester County accounts for almost 55.15% of the planning district's annualized losses. The census blocks bordering the York River and Mobjack Bay have higher loss values as compared to the larger census blocks in the northwest portions of the county. Collective damages between both the York River and Mobjack Bay are nearly equivalent. The southeast portion of the County contains the greatest concentration of loss. The vicinity of Guinea Road and Kings Creek Road; beginning in the locale of Hayes and heading east to Kings Creek being bordered on the north by the Severn River and on the south by the York River exhibits the greatest concentration of loss. Additionally, the land area of Saddlers Neck to Stump Point being bounded on the north by the Northwest Branch Severn River and Willetts Creek to the south exhibits a second concentration of risk. Finally, the peninsula and vicinity of Ware Neck Point -where the Ware River and North River converge – is another location exhibiting a concentration of losses.

Losses in Mathews County are spread throughout the county with a high frequency of census block having damages greater than $50,000 US Dollars along the Chesapeake Bay to include the various harbor/haven inlets and also at the confluences of the Piankatank River in the north as well as Mobjack Bay in the south. Another location that exhibits relatively higher loss estimates includes Roys Point in the area around Daniel Avenue. Ultimately, Mathews County ranks second of the six counties and accounts for 20.4% of the total annualized losses in the MPPDC planning district.

The census blocks bordering the Pamunkey and Mattaponi rivers contain almost all of the annualized damages for King William County with the greatest concentration of losses in the Town of West Point. Wood framed structures across the county account for more than 50% of the losses. The total annualized damages for the Town of West Point is approximately $1.3 million US Dollars. Total annualized losses of the Pamunkey Indian Reservation is approximately $40,000 US Dollars and the Mattaponi Indian Reservation is $14,000 US Dollars. Two (2) locations in the northwestern portion of the County exhibit relatively higher annualized loss values; the two areas are in the vicinity of both Manquin and Aylett with Aylett experiencing the greater losses near $145,000 US Dollars and Manquin having estimated losses of $40,000 US Dollars.

Middlesex County's annualized losses account for 6.3% of the total risk with wood framed structures accounting for nearly 68% of the losses. The census blocks along the Rappahannock River collectively account for the greatest amount of losses within the County. Losses in the vicinity of Mud Creek, Balls Point, The Town of Urbanna, and the confluence with the Chesapeake Bay constitute the areas having the highest loss values. The Town of Urbana has an estimated $300,000 US Dollars in annualized damages and includes the census block having the highest estimated loss ($226,000 US Dollars) within the County. The second highest census block loss ($70,000) is located at the confluence between the Rappahannock River and the Chesapeake Bay in the southeastern portion of the County.

King and Queen County has the lowest annualized loss values for the region, accounting for 3.2% of the total damages. Residential occupancy makes up the majority of the losses in the county. A relatively small group of census blocks along the York River account for most of the damages near $400,000 US Dollars. In comparison, along the Mattaponi River damages are in the range of near $100,000 or roughly one-quarter of the expected damages along the York River. Notwithstanding, a small pocket of development at the end of Limehouse Road along the Mattaponi River downstream of Muddy Point and opposite the Town of West Point is an area with annualized losses near $20,000 US Dollars.The majority of damage within Essex County is along the Rappahannock River with the greatest concentration of annualized losses from the Town of Tappahannock in the north, extending downstream to the vicinity of Wares Warf. Total annualized damages along the length of the Rappahannock are approximately $1.34 million. The concentrated damages from Tappahannock to Wares Point is approximately $0.67 million or nearly one-half of the expected damages along the Rappahannock River. The Town of Tappahannock accounts for approximately $0.34 million or nearly one-half of the expected damages in the area of concentrated damages along the Rappahannock. The county and town combined, account for approximately 5.8% of annualized damages for the MPPDC region.

Comparative Flood Modeling:
Noting the existence of new RiskMAP-based depth grids from recent FEMA studies, presented below are results of running the new coastal-only 1% Annual Chance Flood Hazard. As discussed earlier, the new RiskMAP-based depth grid was not utilized to replace the Hazus Level 1 depth grids. However, the study data (i.e., the same study data that would have been used to create the RiskMAP-based depth grid) was utilized in the Level 1 analysis. Again, this included use of the Stillwater Elevations reported for coastal transects in Table 2 – Transect Data for each FEMA Flood Insurance Study. Consequently, the loss values presented below for general comparison, effectually exhibit that losses are relatively close. Consequently, knowing that losses are relatively close is confirmation that the Hazus Level 1 methodology is quite reasonable for the regional estimations and analyses presented. However, in the event that further analyses at smaller mapping scales (e.g., Parcel-level) are warranted in other projects, it would be advisable to use the RiskMAP-based data.

Table XX. MPPDC Loss Comparison – 1% Coastal (RiskMAP vs. Level 1 Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
MPPDC Region	100YR_RiskMapCstlOnly [A]	$233,744	$128,057	$104,166	$2,220
MPPDC Region	100YR_LVL1CstlOnly [B]	$236,591	$128,430	$106,547	$2,389
Data in Thousands of Dollars					
Notes:					
[A] Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.					
[B] Scenario uses depth grids produced from Hazus Level 1 methodology; NED 1-Arc DEMs, 1 mi² Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.					

Table XX. Essex County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Essex County	100YR_RiskMapCstlOnly [A]	$14,695	$7,541	$7,014	$162
Essex County	100YR_LVL1CstlOnly [B]	$16,421	$8,637	$7,663	$141
Data in Thousands of Dollars					
Notes:					
[A] **Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.**					
[B] **Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi² Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.**					

Table XX. Gloucester County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Gloucester County	100YR_RiskMapCstlOnly [A]	$108,158	$58,259	$49,148	$50,416
Gloucester County	100YR_LVL1CstlOnly [B]	$118,631	$62,714	$55,018	$56,528
Data in Thousands of Dollars					
Notes:					
[A] **Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.**					
[B] **Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi² Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.**					

Table XX. King / Queen County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
King Queen County	100YR_RiskMapCstlOnly [A]	$5,152	$3,094	$2,004	$54
King Queen County	100YR_LVL1CstlOnly [B]	$7,140	$4,375	$2,720	$45
Data in Thousands of Dollars					
Notes:					
[A] **Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.**					
[B] **Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi² Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.**					

Table XX. King William County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
King William County	100YR_LVL1CstlOnly [B]	$16,553	$7,961	$8,489	$163
King William County	100YR_RiskMapCstlOnly [A]	$18,428	$8,564	$9,737	$194
Data in Thousands of Dollars					
Notes:					
[A] Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.					
[B] Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi^2 Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.					

Table XX. Mathews County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Mathews County	100YR_LVL1CstlOnly [B]	$60,614	$34,946	$25,279	$451
Mathews County	100YR_RiskMapCstlOnly [A]	$65,453	$37,867	$27,188	$466
Data in Thousands of Dollars					
Notes:					
[A] Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.					
[B] Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi^2 Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.					

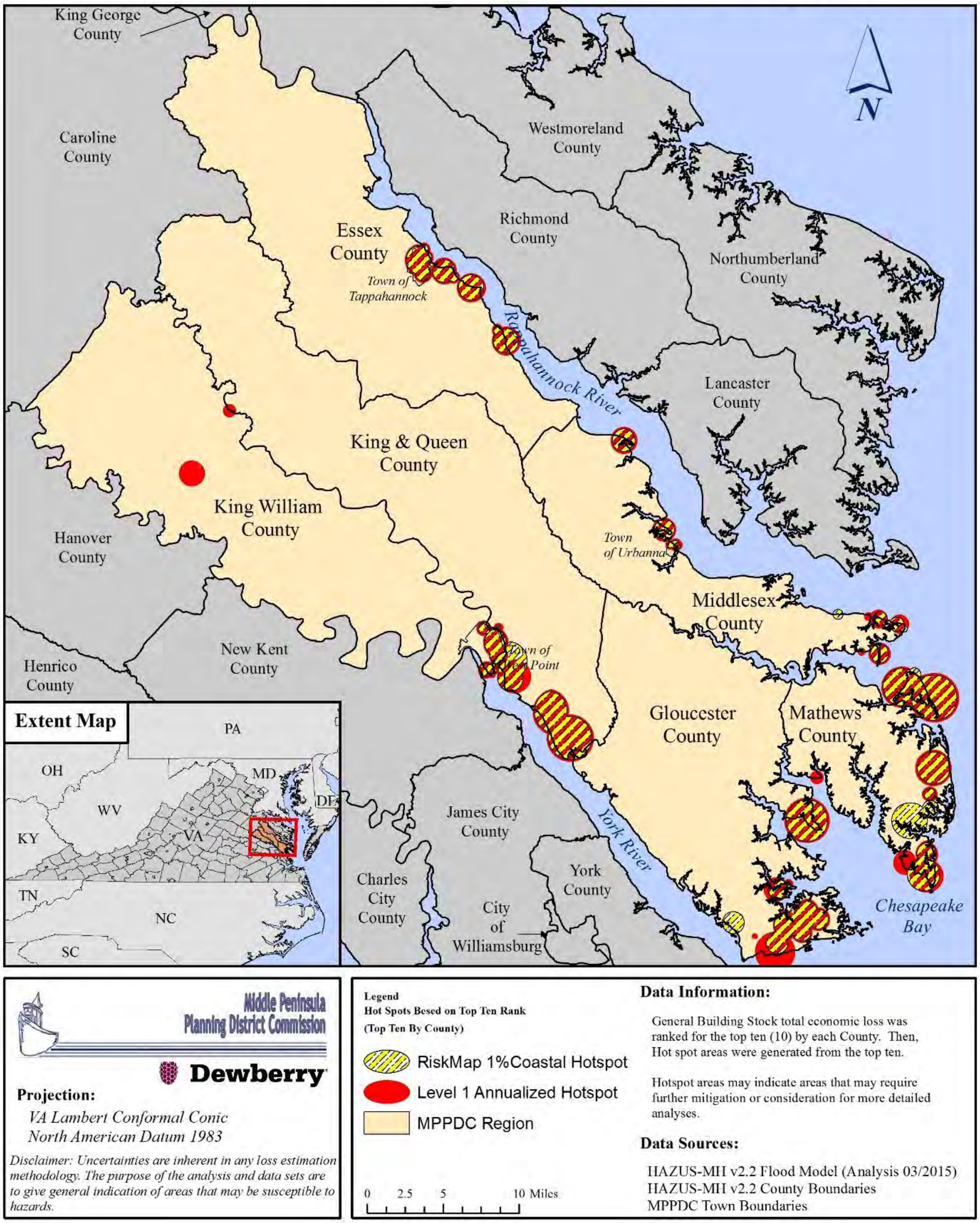
Table XX. Middlesex County Loss Comparison – 1% Coastal (RiskMAP vs. Level I Methodology).

Area	Scenario	Total Loss	Building Loss	Contents Loss	Business Disruption
Middlesex County	100YR_LVL1CstlOnly [B]	$17,232	$9,797	$7,378	$79
Middlesex County	100YR_RiskMapCstlOnly [A]	$21,858	$12,732	$9,075	$76
Data in Thousands of Dollars					
Notes:					
[A] Scenario uses depth grids produced for FEMA RiskMAP Studies by USACE circa March 2015.					
[B] Scenario uses depth grids produced from Hazus Level I methodology; NED 1-Arc DEMs, 1 mi^2 Drainage Threshold, most recent coastal water surfaces from FEMA FIS text (Table 2 – Transect Data) for each respective county.					

A comparison of the "hot spots" that exist form the Level I Annualized and the new RiskMAP-based 1% Annual Chance loss estimates reveals very similar results. Figure XX below, shows the hot spots generated from the two different types of modeling. It can be seen that the new RiskMAP-based analysis shows a number of similarities in the potential flood losses. Any location where the two hot spot types overlap, are locations where the relative risk is considered to be comparative or relatively similar.

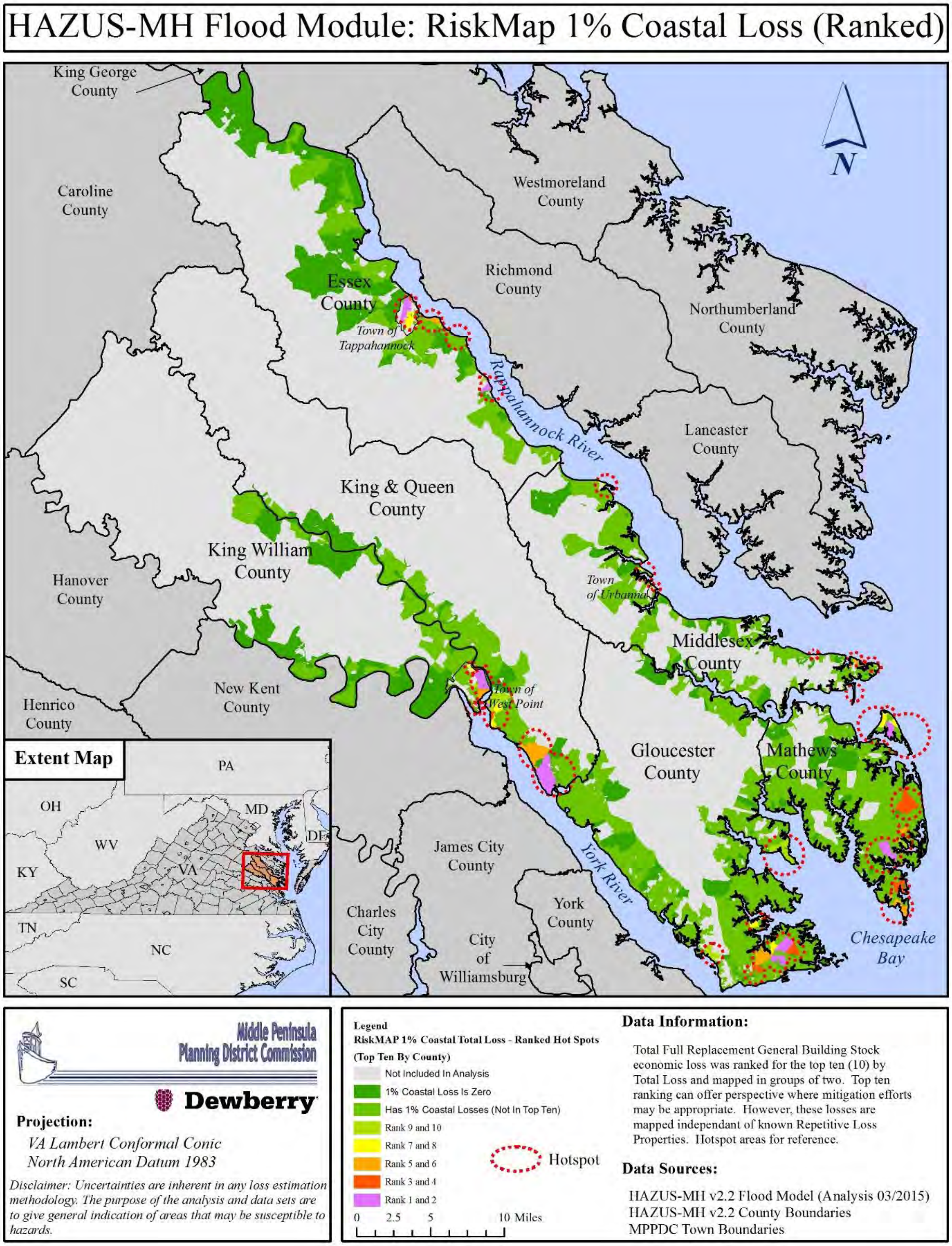
However, it is important to note that the two (2) Level 1 Annualized Hotspots in northwestern King William County (vicinity of Manquin and Aylett) are areas attributed to Riverine flooding influence. Therefore, the RiskMAP 1% Coastal Hotspots will not reveal these same areas as potential hot spots. Consequently, the RiskMAP 1% Coastal Hotspots will reveal the addition of other new areas given the extents of the costal flood hazard (see Figure XX – FEMA digital FIRM & RiskMAP 1% Coastal Depth Grid).

HAZUS-MH Flood Module: Hot Spot Comparison



Given the coastal focus of the RiskMAP study, it can be seen that a few new areas of consideration include the following:

- Middlesex County – an area along the Rappahannock River where the River confluences with Woods Creek.
- Gloucester County – an area along the York River, east of the Carmines Islands and situated between Carmines Island Road (in the west) and Pigeon Hill Road (in the east).
- Mathews County – portions of land on the northern banks of Horn Harbor and also along Winter Harbor.
- King and Queen County – a greater area (as compared to the Level 1 Annualized Hot Spot) in the vicinity of Mattaponi; i.e., confluence of Mattaponi and York Rivers near State Highway 33 (Lewis B. Puller Memorial Highway).


HAZUS-MH Flood Module: RiskMap 1% Coastal Loss (Ranked)
King George County
Caroline County
Westmoreland County
Essex County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Town of West Point
Henrico County
Gloucester County
Mathews County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
James City County
York River
Charles City County
York County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend
RiskMAP 1% Coastal Total Loss - Ranked Hot Spots
(Top Ten By County)
Not Included In Analysis
1% Coastal Loss Is Zero
Has 1% Coastal Losses (Not In Top Ten)
Rank 9 and 10
Rank 7 and 8
Rank 5 and 6
Rank 3 and 4
Rank 1 and 2
Hotspot
0 2.5 5 10 Miles
Data Information:
Total Full Replacement General Building Stock economic loss was ranked for the top ten (10) by Total Loss and mapped in groups of two. Top ten ranking can offer perspective where mitigation efforts may be appropriate. However, these losses are mapped independant of known Repetitive Loss Properties. Hotspot areas for reference.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

Essential Facilities

Level I analysis of essential facilities typically involves using the data provided with Hazus (i.e., Out-of-the-Box). This means the Hazus data of Essential Facilities is used as-is and no local data inputs are utilized. Essential facilities were modeled in this manner which includes the following feature types:

- Medical Care Facilities
- Emergency Operation Centers
- Fire Stations
- Police Stations
- Schools

Essential facilities are typically those facility types that are vital to emergency response and recovery following a disaster. School buildings are included in this category because of the key role they often play in sheltering people displaced from damaged homes. Generally there are very few of each type of essential facilities in a census tract, making it easier to obtain site-specific information for each facility. Thus, damage and loss-of-function are evaluated on a building-by-building basis for this class of structures, even though the uncertainty in each such estimate is large[3].

Figure XX displays the spatial location of the mapped essential facilities as provided with the Hazus software. Thereafter, Figure XX highlights those facilities that are damaged by the Hazus Level 1 multi-frequency flood hazard(s) – thus experiencing estimated damage and loss.

Future versions of this plan can be enhanced, as illustrated in the mitigation actions, with further Level 2 refinements and Level 3 analyses.

[3] Multi-hazard Loss Estimation Methodology HAZUS-MH V2.2, Chapter 1: Introduction, 1-6

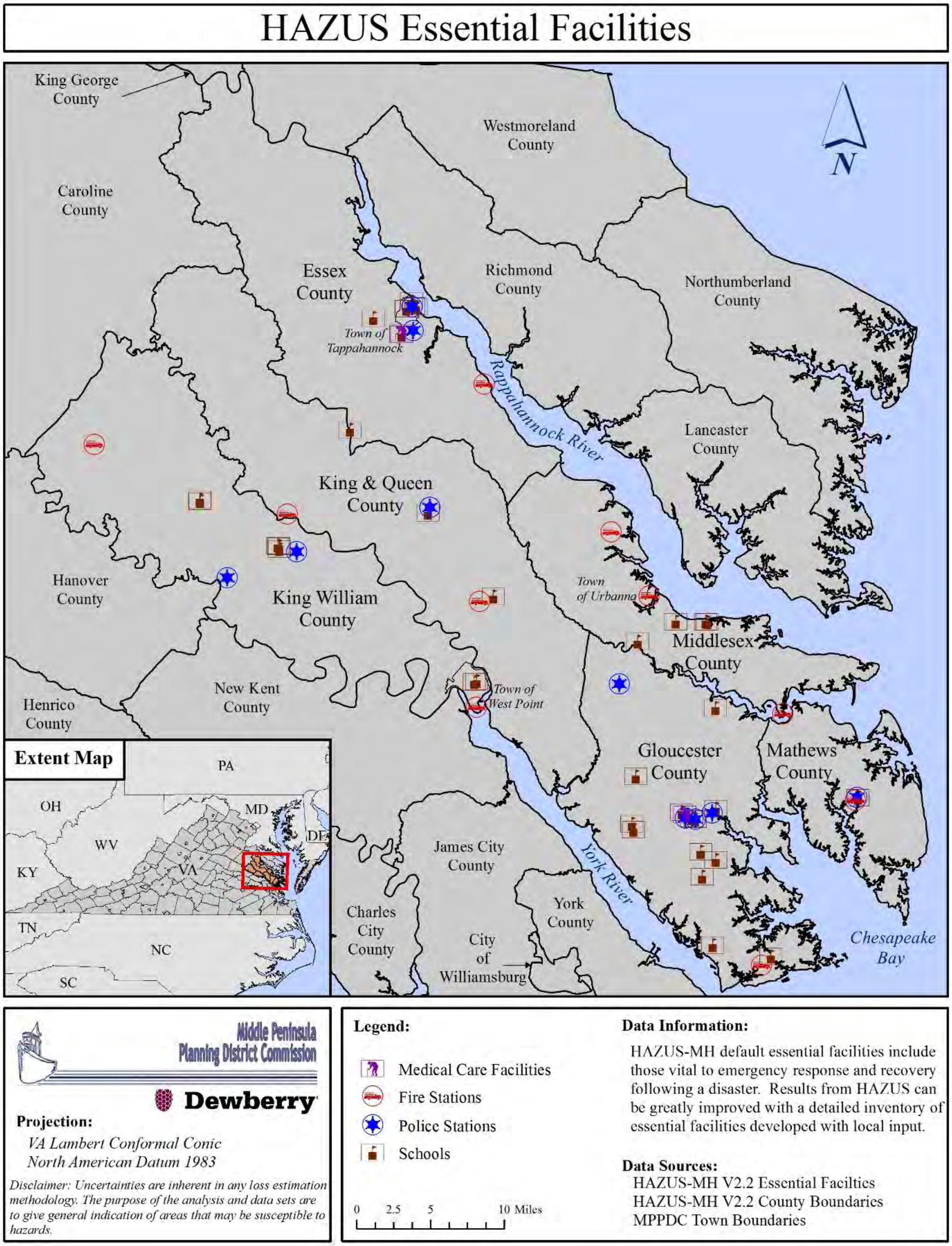
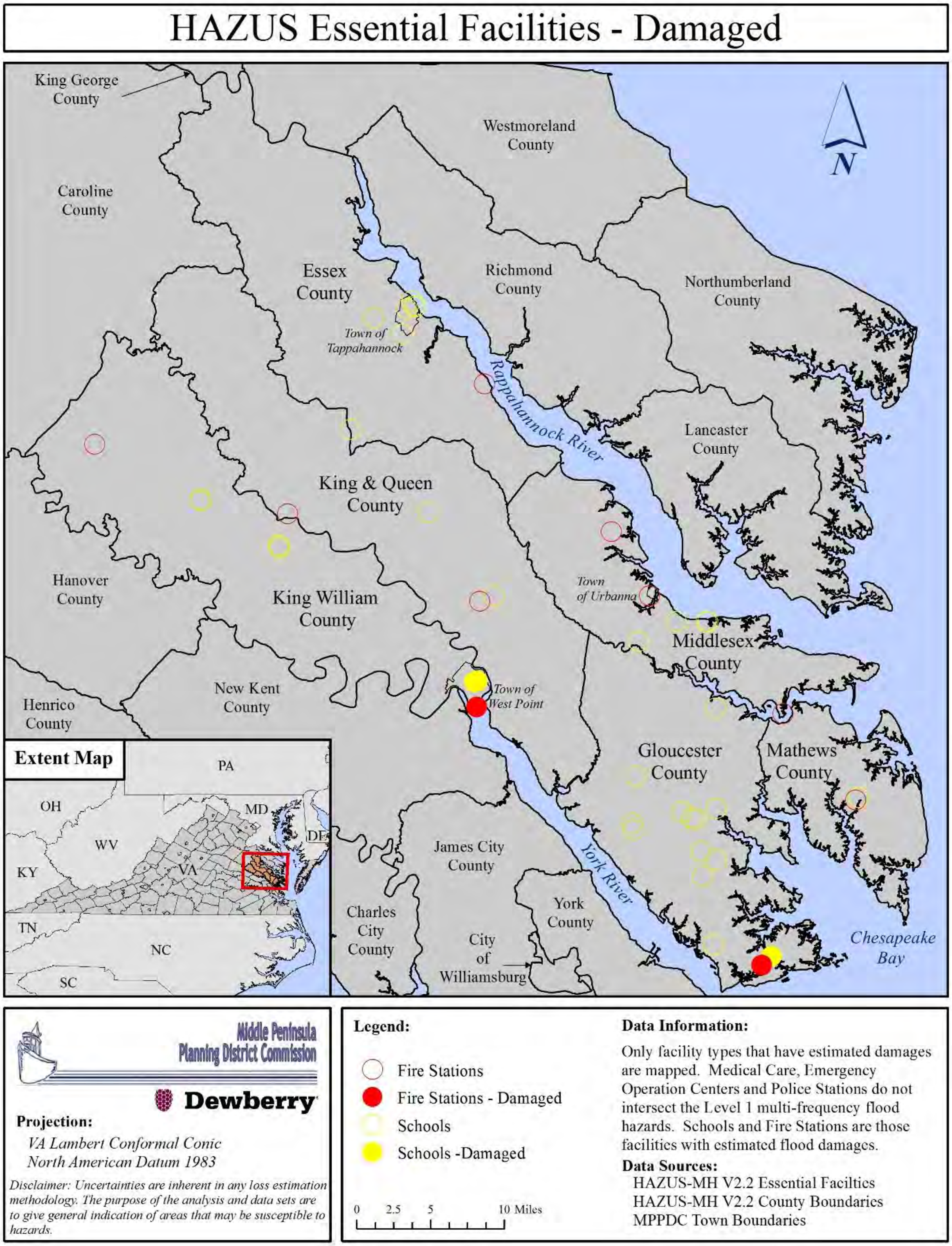

HAZUS Essential Facilities
King George County
Westmoreland County
Caroline County
Essex County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
Town of Urbanna
Hanover County
King William County
Middlesex County
Henrico County
New Kent County
Town of West Point
Gloucester County
Mathews County
James City County
York River
Charles City County
York County
City of Williamsburg
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Medical Care Facilities
Fire Stations
Police Stations
Schools
0 2.5 5 10 Miles
Data Information:
HAZUS-MH default essential facilities include those vital to emergency response and recovery following a disaster. Results from HAZUS can be greatly improved with a detailed inventory of essential facilities developed with local input.
Data Sources:
HAZUS-MH V2.2 Essential Facilties
HAZUS-MH V2.2 County Boundaries
MPPDC Town Boundaries

Table XX. Damaged Essential Facilities and Characteristics of Loss.

Name	City	Return Period	Control Hazard	Bldg DmgPct	Bldg Loss (US Dollar)	Contents DmgPct	Cont Loss (US Dollar)	MaxTime toFull Restoration
ACHILLES ELEM.	Hayes	50-YR	Coastal	4.9	$190,476	26.2	$1,028,573	480 days
ACHILLES ELEM.	Hayes	100-YR	Coastal	6.7	$261,818	36.2	$1,420,380	480 days
ACHILLES ELEM.	Hayes	500-YR	Coastal	18.8	$737,641	81.4	$3,194,153	720 days
WEST POINT MIDDLE	West Point	500-YR	Coastal	5.5	$133,548	29.8	$722,392	480 days
WEST POINT ELEM.	West Point	500-YR	Coastal	3.1	$124,359	16.5	$671,537	481 days
WEST POINT HIGH	West Point	500-YR	Coastal	0.5	$15,976	2.4	$86,268	482 days
West Point Volunteer Fire Department & R	West Point	500-YR	Coastal	1.8	$ -	2.0	$ -	483 days
Abingdon Volunteer Fire and Rescue Inc.	Hayes	25-YR	Coastal	9.9	$ -	19.4	$ -	484 days
Abingdon Volunteer Fire and Rescue Inc.	Hayes	50-YR	Coastal	10.9	$ -	35.8	$ -	485 days
Abingdon Volunteer Fire and Rescue Inc.	Hayes	100-YR	Coastal	11.2	$ -	42.0	$ -	486 days
Abingdon Volunteer Fire and Rescue Inc.	Hayes	500-YR	Coastal	27.7	$ -	100.0	$ -	720 days

NOTES:

Fire Station facilities in the stock Hazus Data do not have estimated replacement values associated with the facilities; therefore estimated dollar losses are NULL or void of any valid values.


HAZUS Essential Facilities - Damaged
King George County
Westmoreland County
Caroline County
Essex County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
Hanover County
King William County
Town of Urbanna
Middlesex County
New Kent County
Town of West Point
Henrico County
Gloucester County
Mathews County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
James City County
York River
Charles City County
York County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Fire Stations
Fire Stations - Damaged
Schools
Schools -Damaged
0 2.5 5 10 Miles
Data Information:
Only facility types that have estimated damages are mapped. Medical Care, Emergency Operation Centers and Police Stations do not intersect the Level 1 multi-frequency flood hazards. Schools and Fire Stations are those facilities with estimated flood damages.
Data Sources:
HAZUS-MH V2.2 Essential Facilties
HAZUS-MH V2.2 County Boundaries
MPPDC Town Boundaries

Potential Mitigation Actions:

The potential mitigation actions noted are those that are Hazus-specific and would benefit refinement of Hazus analyses. The previous Plan update included the following items (below). Those items that have been accomplished in the current Plan update are symbolized with a check-mark (☑) and those that still remain for future efforts (☐). New potential Hazus Mitigation actions are denoted with the following (➢).

- ☑ Complete Hazus flood runs for the 1 sq mi threshold. In most cases, this will need to be done on priority stream reaches as the program does not run efficiently at this level.
- ☑ Re-run Hazus for plan update to reflect 2010 census data.

- ☐ Refine and update data sets for GBS and essential facilities.
    - Improvements in the future should aim to further refine the building stock. Notably, one improvement should include adding any new development that may not have been in the land use/land cover data; e.g., new housing developments, new construction, etc…
    - Perform localized building-level assessments in known areas of loss and or areas subject to likely losses.

Hurricane Wind Analysis

The hurricane wind analysis for the HIRA was completed using the FEMA Hazus – MH V2.2 software. The model uses state of the art wind field models, calibrated and validated hurricane data. Wind speed has been calculated as a function of central pressure, translation speed, and surface roughness. This assessment has been completed for Probabilistic Level 1 analysis. The standard methodology of defining loss potential for any given hazard, includes annualizing the potential over a series of statistical return periods. Annualization is the mathematical method of converting individual losses to a weighted-average that may be experienced in any given year. The standard probabilistic scope pertaining to Hazus Level 1 hurricane wind risk corresponds to annualizing the 0.1%, 0.2%, 0.5%, 1%, 2%, 5%, and 10% wind return periods. In layman's-terms these same annual-chance return periods are often described as the 1,000-year, 500-year, 200-year, 100-year, 50-year, 20-year and 10-year events as shown in Table XX below:

Table XX. Annual probability based on wind recurrence intervals.

Wind Recurrence Interval	Annual Chance of Occurrence
10 year	10.0%
20 year	5.0%
50 year	2.0%
100 year	1.0%
200 year	0.5%
500 year	0.2%
1000 year	0.1%

Practically, these statistical events represent the chance of being equaled or exceeded in any given year; i.e., the likelihood that a particular event with a given intensity occurs on average at least once every x-years. Once each of these statistical return periods are calculated, an annualized value is computed thus offering a perspective for any given year.

In addition to the Level I probabilistic methodology employed, Level I analysis is performed on stock data provided with the Hazus software; i.e., no local data inputs. This is an acceptable level of information for mitigation planning; future versions of this plan can be enhanced, as illustrated in the mitigation actions, with additional Level I scenarios and/or Level 2 and 3 analyses. Dollar values shown in this report should only be used to represent cost of large aggregations of building types. Highly detailed, building specific, loss estimations have not been completed for this analysis as they require additional local data inputs. Note that combined wind, storm surge and wave-type scenarios have not been implemented in this Plan update however, the Flood modeling includes various scenarios that include the effects of storm surge and wave-action. Storm surge risk is discussed in Section XX and coastal flooding in section XX of this plan.

Loss estimation for this Hazus module is based on specific input data. The first type of data includes square footage of buildings for specified types or population. The second type of data includes information on the local economy that is used in estimating losses. Table XX displays the economic loss categories used to calculate annualized losses by Hazus.

Table XX. Hazus direct economic loss categories and descriptions.

Category Name	Description of Data Input into Model	Hazus Output
Building	Cost per sq ft to repair damage by structural type and occupancy for each level of damage	Cost of building repair or replacement of damaged and destroyed buildings
Contents	Replacement value by occupancy	Cost of damage to building contents
Inventory	Annual gross sales in $ per sq ft	Loss of building inventory as contents related to business activities
Relocation	Multiple factors; primarily a function of Rental Costs ($/ft^2/month) for non-entertainment buildings where damage ≥10%	Relocation expenses (for businesses and institutions); disruption costs to building owners for temporary space.
Income	Income in $ per sq ft per month by occupancy	Capital-related incomes losses as a measure of the loss of productivity, services, or sales
Rental	Rental costs per month per sq ft by occupancy	Loss of rental income to building owners
Wage	Wages in $ per sq ft per month by occupancy	Employee wage loss as described in income loss

A probabilistic scenario Hazus analysis was completed using the planning district as the study area. The individual county results have been derived from this data set.

Middle Peninsula currently has approximately 43,501 structures with an estimated exposure value of approximately $17.7 billion. Average estimated replacement value of buildings in the study area range from $94,000 to $297,000, with the mean approximation value of $134,000 [4]. Eighty-one percent of the planning district's general occupancy is categorized as residential, followed by commercial (12%). Table XX below provides inventory information for each of the six counties that were included in the analysis. Gloucester County occupies a large percentage (40%) of the building stock exposure for the region.

Table XX. Building stock exposure for general occupancies by county.

County	Residential	Commercial	Industrial	Agriculture	Religion	Govt.	Education	Total
Gloucester	$5,698,054	$831,318	$147,429	$32,557	$84,190	$32,437	$190,065	$7,016,050
King William	$2,463,239	$274,254	$110,725	$32,549	$41,687	$24,273	$24,786	$2,971,513
Middlesex	$2,151,683	$354,607	$65,244	$14,045	$26,670	$11,736	$40,679	$2,664,664
Essex	$1,578,275	$402,650	$146,178	$25,395	$28,679	$18,661	$31,423	$2,231,261
Mathews	$1,566,770	$149,340	$45,066	$9,877	$19,875	$6,830	$12,042	$1,809,800
King & Queen	$886,914	$52,850	$29,064	$6,710	$19,927	$2,968	$7,284	$1,005,717
Total	$14,344,935	$2,065,019	$543,706	$121,133	$221,028	$96,905	$306,279	$17,699,005
All values are in thousands of dollars								

Building stock exposure is also classified by building type. General Building Types (GBTs) have been developed as a means to classify the different buildings types. This provides an ability to differentiate between buildings with substantially different damage and loss characteristics. Model building types represent the average characteristics of buildings in a class. The damage and loss prediction models are developed for model building types and the estimated performance is based upon the "average characteristics" of the total population of buildings within each class. Five general classifications have been established, including wood, masonry, concrete, steel and manufactured homes (MH). A brief description of the building types is available in Table XX.

Table XX. Hazus General Building Type classes.

General Building Type	Description
Wood	Wood frame construction
Masonry	Reinforced or unreinforced masonry construction
Steel	Steel frame construction
Concrete	Cast-in-place or pre-cast reinforced concrete construction
MH	Factory-built residential construction

[4] Previous Plan values adjusted per BLS CPI Inflation Calculator (2000 to 2010) to match Hazus/Census years.

Wood construction represents the majority (61%) of building types in the planning district. Masonry construction accounts for a quarter of the building type exposure. Table XX below provides building stock exposure for the five main building types.

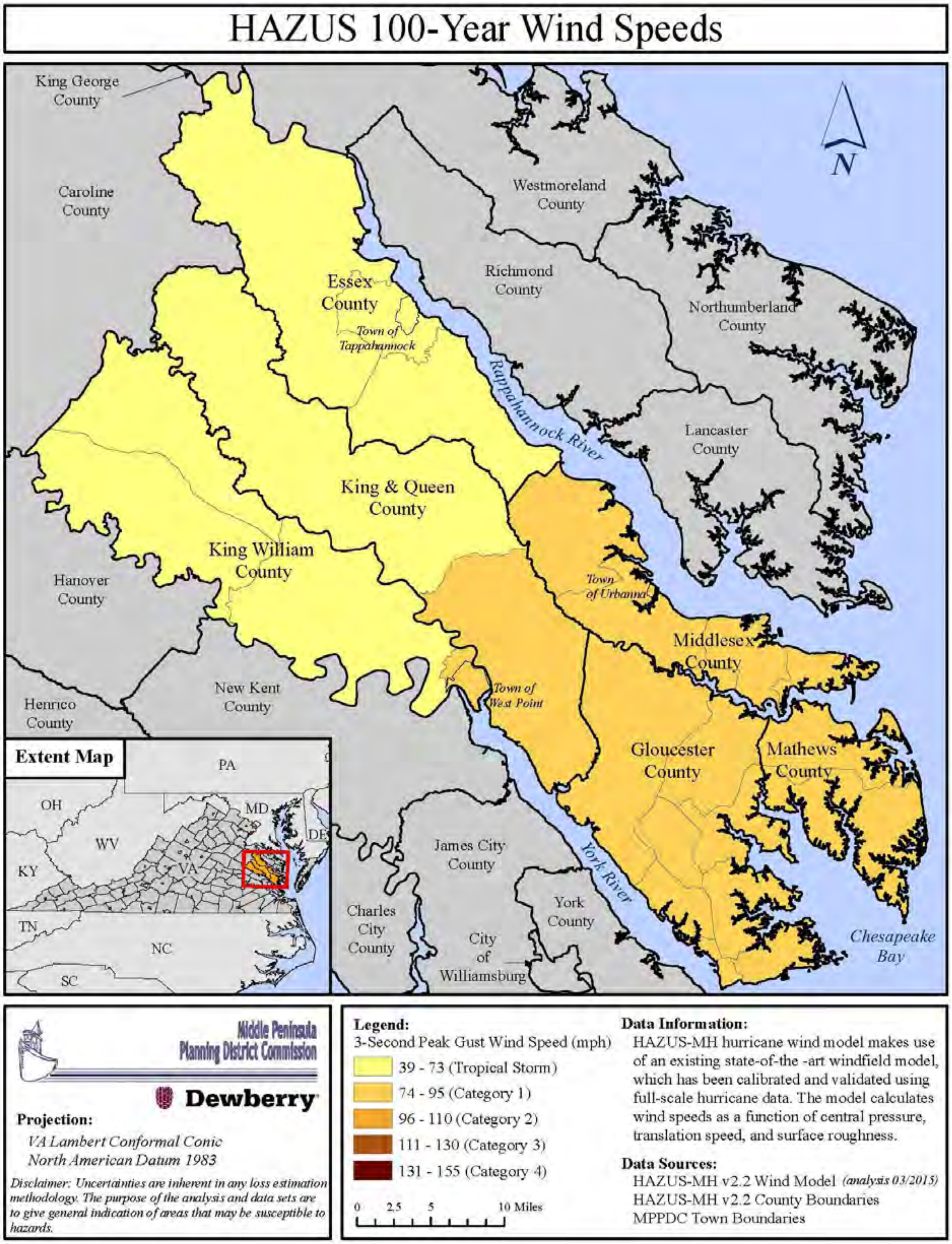
Table XX. Building stock exposure for general building type by county.

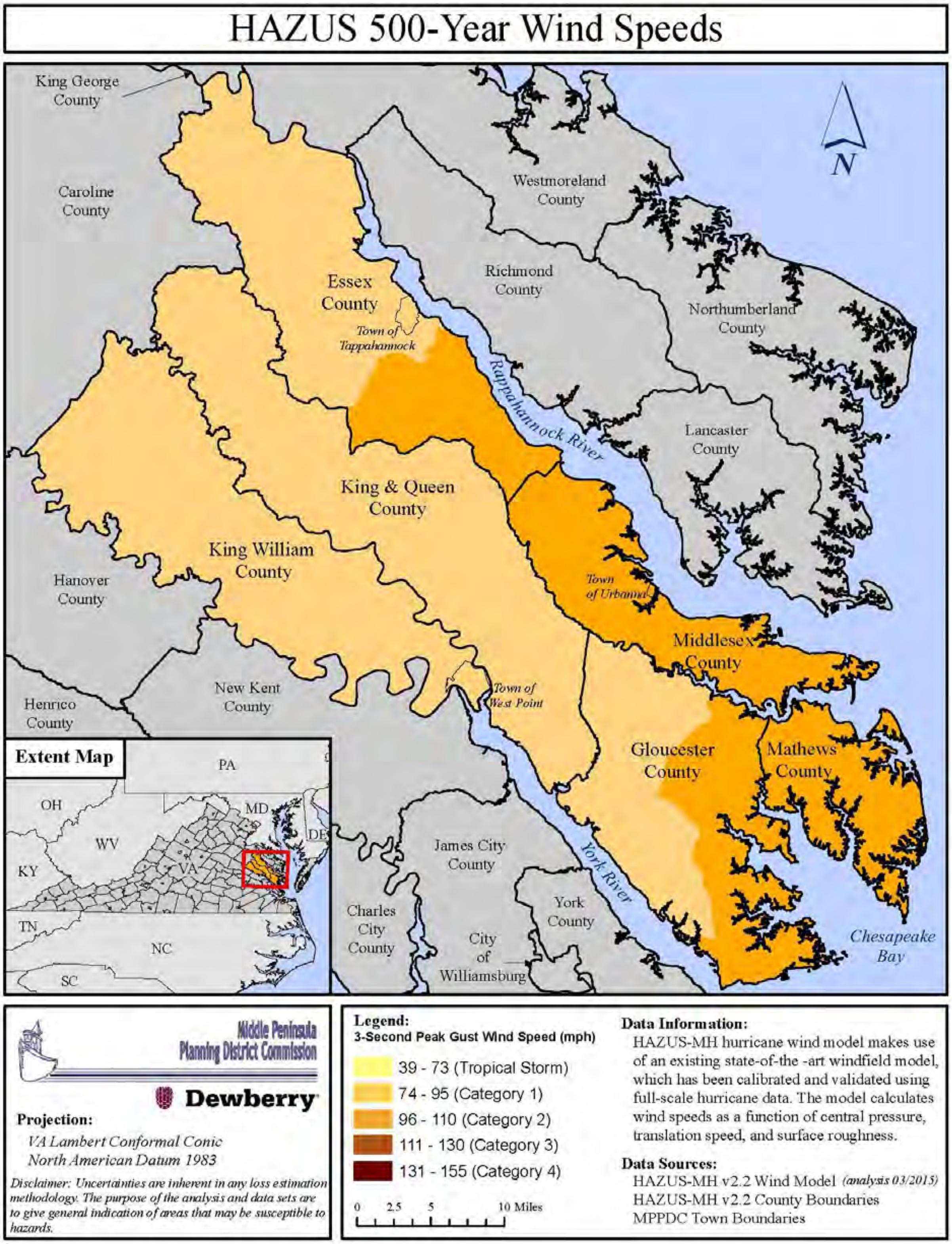
County	Wood	Masonry	Concrete	Steel	Manufactured Home	Total
Gloucester	$4,338,118	$1,782,044	$177,833	$591,235	$126,913	$7,016,143
King William	$1,895,656	$751,978	$61,374	$227,445	$35,155	$2,971,608
Middlesex	$1,631,388	$678,395	$67,789	$225,948	$61,315	$2,664,835
Essex	$1,202,922	$558,827	$102,763	$319,225	$47,615	$2,231,352
Mathews	$1,166,398	$450,836	$32,534	$113,035	$47,165	$1,809,968
King & Queen	$661,413	$247,318	$11,118	$49,521	$36,527	$1,005,897
Total	$10,895,895	$4,469,398	$453,411	$1,526,409	$354,690	$17,699,803
All values are in thousands of dollars						

Multi-frequency Hurricane Modeling – Probabilistic Level 1 methodology
Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities for the 10-, 20-, 50-, 100-, 200-, 500-, and 1000-year return periods. The following figures illustrate the 3-second peak gust wind speeds for the 100-, 500-, and 1000-year return periods. Wind speeds are based on estimated 3-second gusts in open terrain at 10 meters above the ground at the centroid of each census track. Buildings that must be designed for a 100-year mean recurrence interval wind event include[5]:

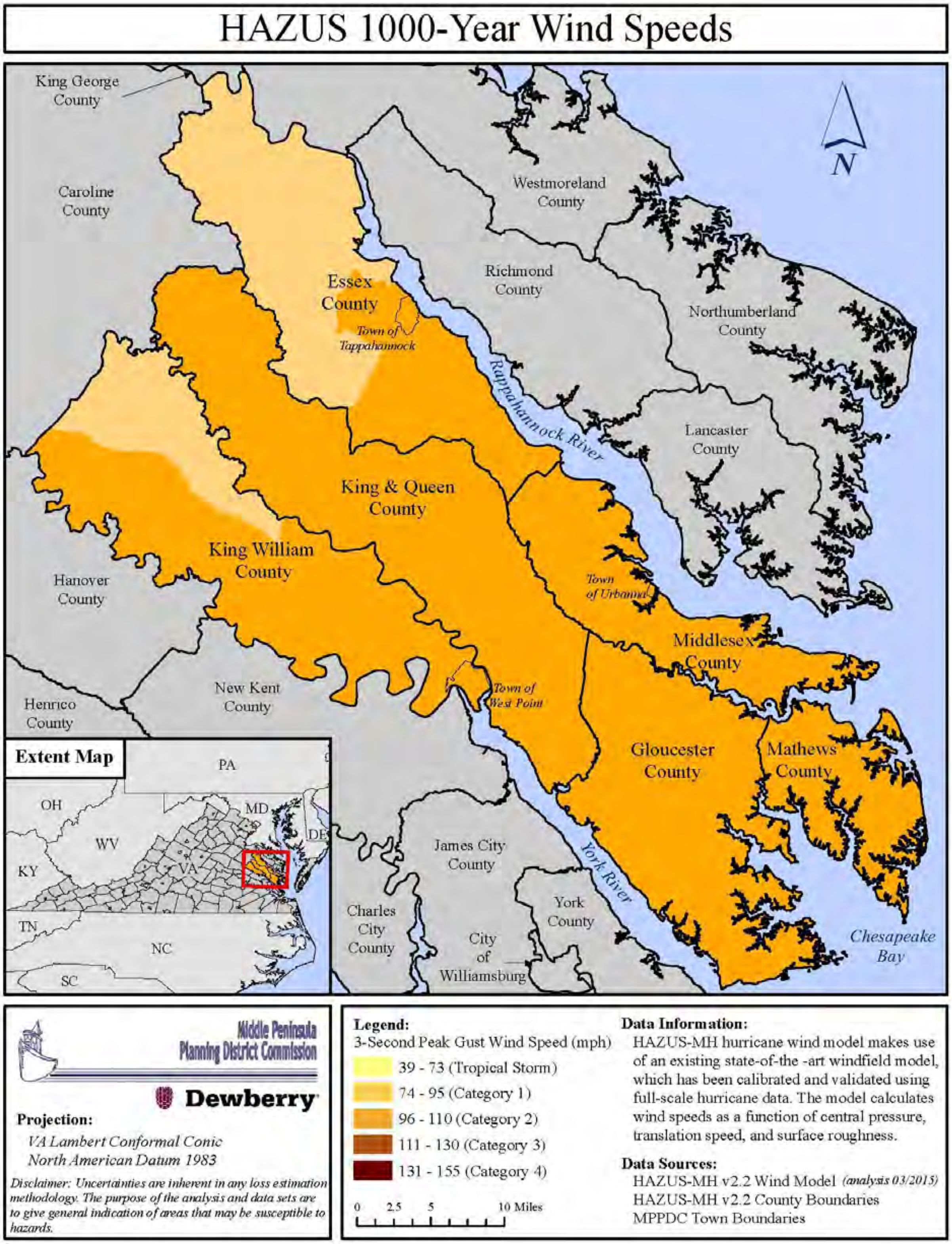
- Buildings where more than 300 people congregate in one area
- Buildings that will be used for hurricane or other emergency shelter
- Buildings housing a day care center with capacity greater than 150 occupants
- Buildings designed for emergency preparedness, communication, or emergency operation center or response
- Buildings housing critical national defense functions
- Buildings containing sufficient quantities of hazardous materials

[5] Whole Building Design Guide (WBDG) Wind Safety of the Building Envelop by Tom Smith 5/26/2008


HAZUS 100-Year Wind Speeds
King George County
Caroline County
Westmoreland County
Richmond County
Northumberland County
Essex County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
Henrico County
New Kent County
Town of West Point
Gloucester County
Mathews County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
3-Second Peak Gust Wind Speed (mph)
39 - 73 (Tropical Storm)
74 - 95 (Category 1)
96 - 110 (Category 2)
111 - 130 (Category 3)
131 - 155 (Category 4)
0 2.5 5 10 Miles
Data Information:
HAZUS-MH hurricane wind model makes use of an existing state-of-the -art windfield model, which has been calibrated and validated using full-scale hurricane data. The model calculates wind speeds as a function of central pressure, translation speed, and surface roughness.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries



HAZUS 500-Year Wind Speeds
King George County
Caroline County
Westmoreland County
Essex County
Town of Tappahannock
Richmond County
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Henrico County
Town of West Point
Gloucester County
Mathews County
James City County
York River
Charles City County
City of Williamsburg
York County
Chesapeake Bay
N
Extent Map
PA
OH
MD
DE
WV
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
3-Second Peak Gust Wind Speed (mph)
39 - 73 (Tropical Storm)
74 - 95 (Category 1)
96 - 110 (Category 2)
111 - 130 (Category 3)
131 - 155 (Category 4)
0 2.5 5 10 Miles
Data Information:
HAZUS-MH hurricane wind model makes use of an existing state-of-the -art windfield model, which has been calibrated and validated using full-scale hurricane data. The model calculates wind speeds as a function of central pressure, translation speed, and surface roughness.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS 1000-Year Wind Speeds
King George County
Caroline County
Westmoreland County
Richmond County
Essex County
Town of Tappahannock
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
Henrico County
New Kent County
Town of West Point
Gloucester County
Mathews County
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Extent Map
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KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
3-Second Peak Gust Wind Speed (mph)
39 - 73 (Tropical Storm)
74 - 95 (Category 1)
96 - 110 (Category 2)
111 - 130 (Category 3)
131 - 155 (Category 4)
0 2.5 5 10 Miles
Data Information:
HAZUS-MH hurricane wind model makes use of an existing state-of-the -art windfield model, which has been calibrated and validated using full-scale hurricane data. The model calculates wind speeds as a function of central pressure, translation speed, and surface roughness.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

General Building Stock Loss Estimation

The probabilistic Hazus-MH hurricane analysis predicts that the Middle Peninsula can annually expect close to $2,516,200 US Dollars in damages due to hurricane wind events. Property or "capital stock" losses of $2,359,300 US Dollars make up about 94% of the damages. This includes the values for buildings, contents, and inventory. Business interruption accounts for approximately $156,900 US Dollars of the annualized losses, or 6%, and includes relocation, income, rental, and wage costs.

Table XX illustrates the expected annualized losses broken down by county. Gloucester County has the highest annualized loss, $1,242,600 US Dollars, accounting for 49% of the total losses for Middle Peninsula. The majority of the expected damages can be attributed to building and content value.

Mathews County has the second highest loss, $464,930 US Dollars, accounting for 18% of the total annualized losses for Middle Peninsula.

Building value accounts for approximately 66% of the expected annualized damages; residential occupancy makes up the vast majority of these losses. More than 70% of the buildings are categorized as wood frame and 22% masonry construction. Tables XX and XX summarize the property losses and business interruption losses shown by occupancy and building type. The slight differences in the annualized losses for building type and occupancy can be attributed to the Hazus classification methodology.

Table XX. County based Hazus annualized loss by all building and occupancy types.

County	Building	Content	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Gloucester	$801.30	$371.43	$0.67	$45.98	$2.89	$15.13	$5.22	$1,242.61
Mathews	$291.59	$145.16	$0.22	$19.93	$0.76	$6.31	$0.96	$464.93
King William	$121.47	$37.33	$0.22	$6.17	$0.27	$2.04	$0.76	$168.26
Middlesex	$263.93	$69.84	$0.25	$24.91	$1.11	$8.21	$1.60	$369.86
King & Queen	$66.90	$27.37	$0.09	$3.70	$0.08	$1.07	$0.13	$99.35
Essex	$111.93	$49.34	$0.27	$6.40	$0.38	$2.19	$0.69	$171.21
Annualized Loss	**$1,657.12**	**$700.47**	**$1.73**	**$107.10**	**$5.49**	**$34.96**	**$9.35**	**$2,516.23**
All values are in thousands of dollars								

Table XX. Annualized loss by general building type in the Middle Peninsula Region.

Building Type	Building	Contents	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Wood	$1,207.35	$550.42	$0.18	$71.02	$1.19	$22.84	$1.76	**$1,853.00**
Masonry	$368.21	$126.01	$0.35	$26.27	$1.62	$8.91	$2.85	**$531.38**
MH	$49.06	$10.01	$0	$4.41	$0	$0.67	$0	**$64.14**
Steel	$26.61	$11.64	$0.99	$4.28	$2.20	$1.85	$3.72	**$47.57**
Concrete	$5.89	$2.39	$0.21	$1.12	$0.48	$0.69	$1.03	**$10.79**
Annualized Loss	**$1,657.12**	**$700.47**	**$1.73**	**$107.10**	**$5.49**	**$34.96**	**$9.35**	**$2,506.88**
% of Ann. Loss	**66.10%**	**27.94%**	**0.07%**	**4.27%**	**0.22%**	**1.39%**	**0.37%**	*Hazus-MH (V2.2) results*
All values (except percentages) are in thousands of dollars								

Table XX: Annualized loss by general occupancy type in the Middle Peninsula Region.

Occupancy Type	Building	Contents	Inventory	Relocation	Income	Rental	Wage	Annualized Loss
Residential	$1,585.15	$671.08	$0	$97.18	$0.05	$31.23	$0.11	**$2,384.69**
Commercial	$39.99	$14.15	$0.37	$6.25	$4.30	$3.36	$4.88	**$68.42**
Industrial	$10.77	$7.10	$1.24	$0.71	$0.14	$0.11	$0.23	**$20.08**
Non-Profit	$5.47	$0.90	$0	$0.91	$0.54	$0.08	$1.27	**$7.90**
Education	$5.42	$3.09	$0	$1.08	$0.35	$0.08	$0.83	**$10.04**
Government	$1.42	$0.62	$0	$0.28	$0.02	$0.06	$1.83	**$2.40**
Agricultural	$2.09	$1.64	$0.12	$0.40	$0.01	$0.02	$0.01	**$4.28**
Annualized Loss	**$1,650.32**	**$698.58**	**$1.73**	**$106.81**	**$5.41**	**$34.95**	**$9.17**	**$2,497.81**
% of Ann. Loss	**65.83%**	**27.97%**	**0.07%**	**4.28%**	**0.22%**	**1.40%**	**0.37%**	*Hazus-MH (V2.2) results*
All values (except percentages) are in thousands of dollars								

Residential occupancy accounts for the majority of the damages. Tables XX and XX summarize the annualized loss values by county. These values are broken down by building type and general occupancy for comparison. Total exposure has been included as a reference point for damages. Wood structures account for the greatest percentage (62%) of the total annualized damages, with masonry structures next representing near 25% of the total annualized damages.

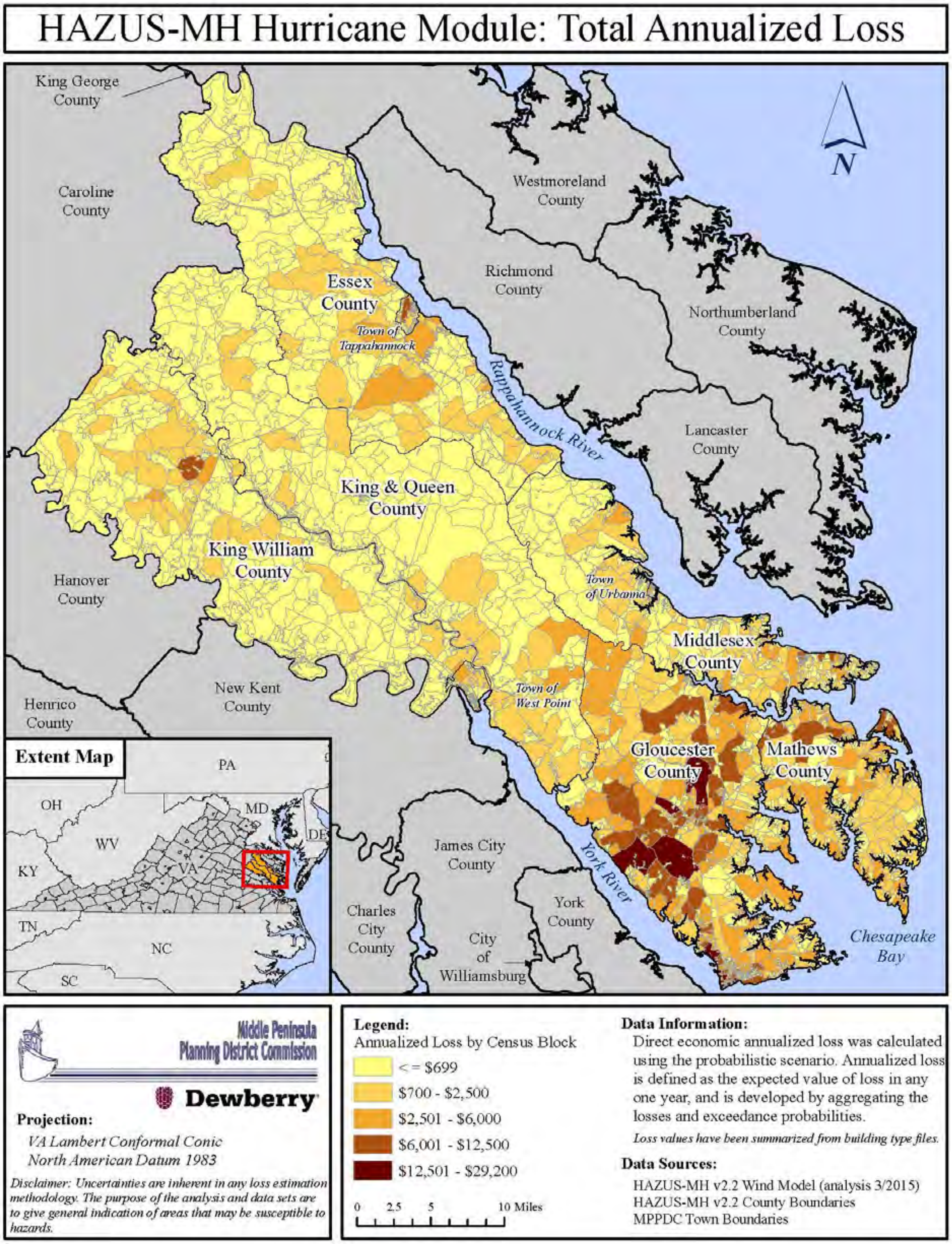
Table XX. County based Hazus annualized loss by general building type.

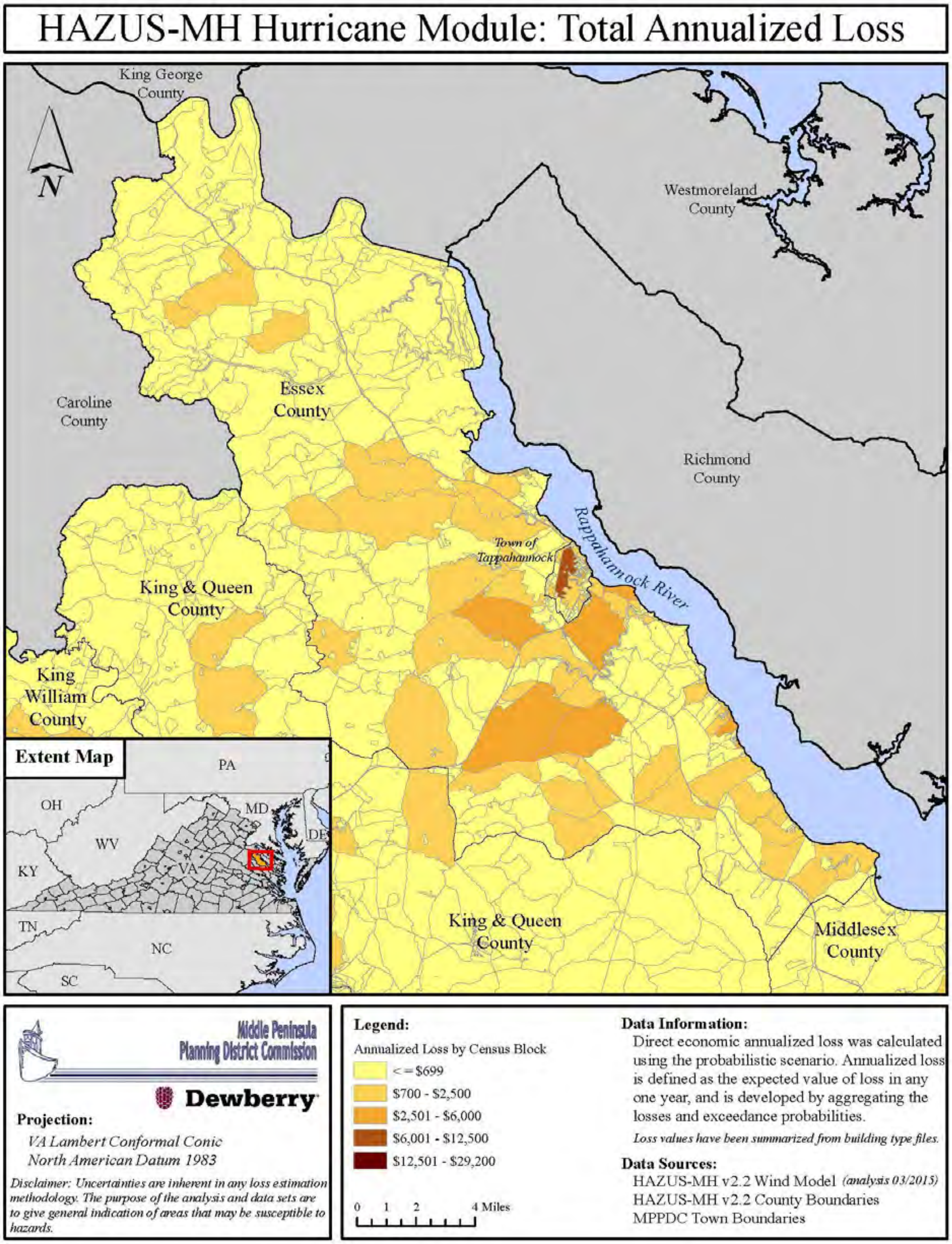
County	Total Exposure	Concrete	Masonry	Manufactured Homes	Steel	Wood	Annualized Loss
Gloucester	$7,016,050	$6.27	$257.37	$27.17	$26.51	$925.30	$1,242.61
Mathews	$1,809,800	$1.26	$93.60	$14.09	$6.15	$349.84	$464.93
Middlesex	$2,664,664	$1.99	$87.52	$12.50	$9.04	$258.82	$369.86
Essex	$2,231,261	$1.20	$37.51	$4.48	$5.01	$123.01	$171.21
King William	$2,971,513	$0.90	$38.42	$2.38	$3.56	$123.01	$168.26
King & Queen	$1,005,717	$0.19	$19.81	$3.53	$1.03	$74.79	$99.35
Annualized Loss		$11.82	$534.23	$64.14	$51.29	$1,854.75	$2,516.23
% of Annualized Loss		0.5%	21.2%	2.5%	2.0%	73.7%	*Hazus-MH (V2.2) results*
% of Total Exposure		< 1%	< 1%	< 1%	< 1%	< 1%	
All values (except percentages) are in thousands of dollars							

Table XX. County based Hazus annualized loss by general occupancy type.

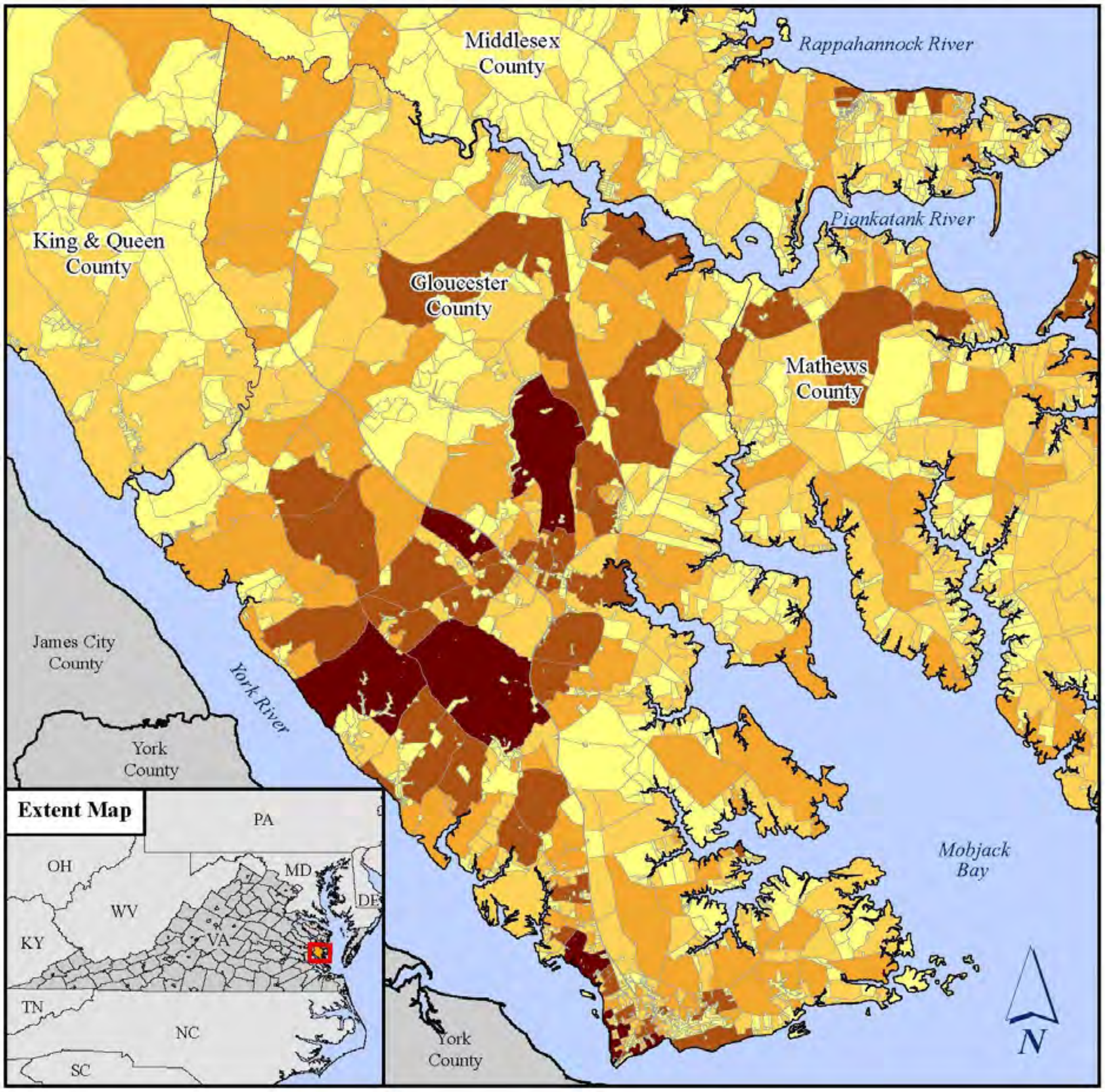
County	Total Exposure	Residential	Commercial	Industrial	Non-Profit	Education	Government	Agriculture	Annualized Loss
Gloucester	$7,016,050	$1,174.83	$37.91	$7.07	$4.62	$11.14	$2.20	$1.67	$1,239.45
Essex	$2,231,261	$449.32	$8.26	$3.26	$1.41	$0.38	$0.31	$0.70	$463.63
Middlesex	$2,664,664	$345.81	$15.04	$3.02	$1.40	$1.29	$0.60	$0.63	$367.80
Mathews	$1,809,800	$159.34	$6.92	$3.25	$0.50	$0.45	$0.36	$0.55	$171.37
King William	$2,971,513	$158.87	$4.08	$2.63	$0.80	$0.35	$0.72	$0.59	$168.03
King and Queen	$1,005,717	$96.63	$1.09	$1.08	$0.44	$0.05	$0.05	$0.14	$99.49
Annualized Loss		$2,384.80	$73.30	$20.32	$9.17	$13.66	$4.23	$4.29	$2,509.77
% of Annualized Loss		95.02%	2.92%	0.81%	0.37%	0.54%	0.17%	0.17%	*Hazus-MH (V2.2) results*
% of Exposure		< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	< 1%	
All values (except percentages) are in thousands of dollars									

Figures XX through XX on the following pages show the total annualized losses mapped for the planning district and individual counties.


HAZUS-MH Hurricane Module: Total Annualized Loss
King George County
Caroline County
Westmoreland County
Essex County
Town of Tappahannock
Richmond County
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Henrico County
Town of West Point
Gloucester County
Mathews County
Extent Map
PA
OH
MD
WV
DE
VA
KY
TN
NC
SC
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
<= $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 2.5 5 10 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 3/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Hurricane Module: Total Annualized Loss
King George County
N
Westmoreland County
Caroline County
Essex County
Richmond County
Rappahannock River
Town of Tappahannock
King & Queen County
King William County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
King & Queen County
Middlesex County
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
<= $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 1 2 4 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

HAZUS-MH Hurricane Module: Total Annualized Loss



Middle Peninsula Planning District Commission

Dewberry

Projection:

VA Lambert Conformal Conic
North American Datum 1983

Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.

Legend:

Annualized Loss by Census Block

- < = $699
- $700 - $2,500
- $2,501 - $6,000
- $6,001 - $12,500
- $12,501 - $29,200

0 1 2 4 Miles

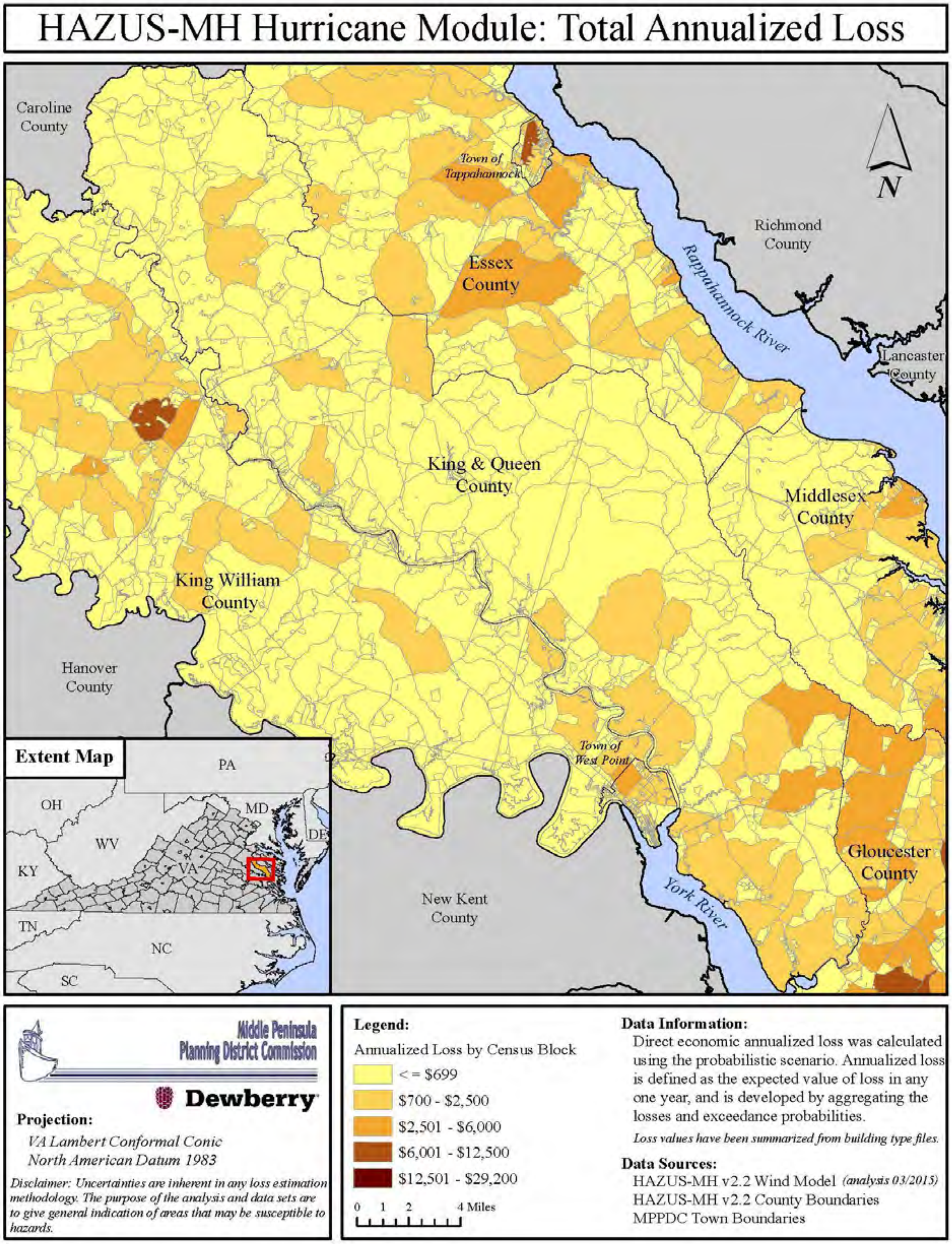
Data Information:

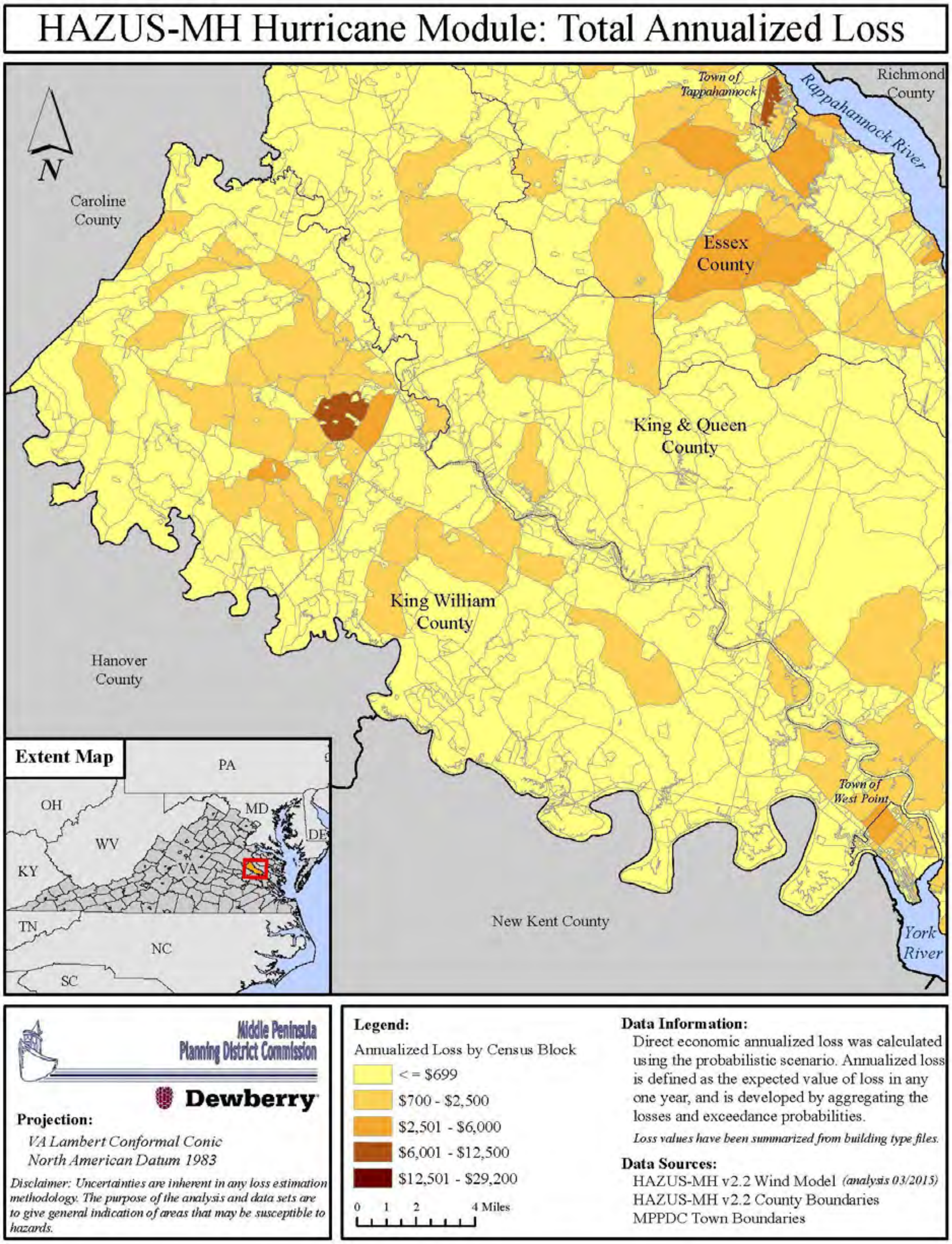
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.

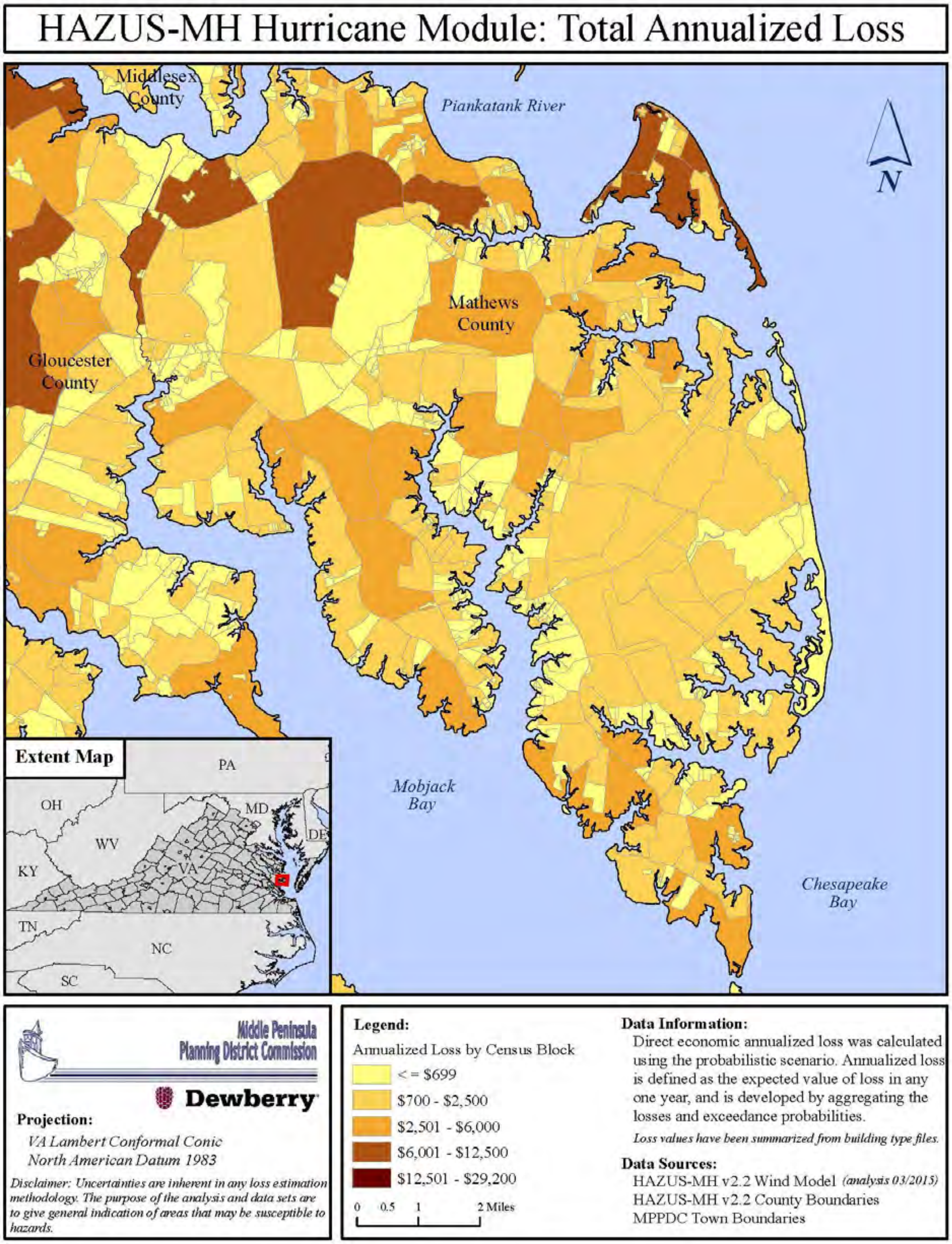
Loss values have been summarized from building type files.

Data Sources:

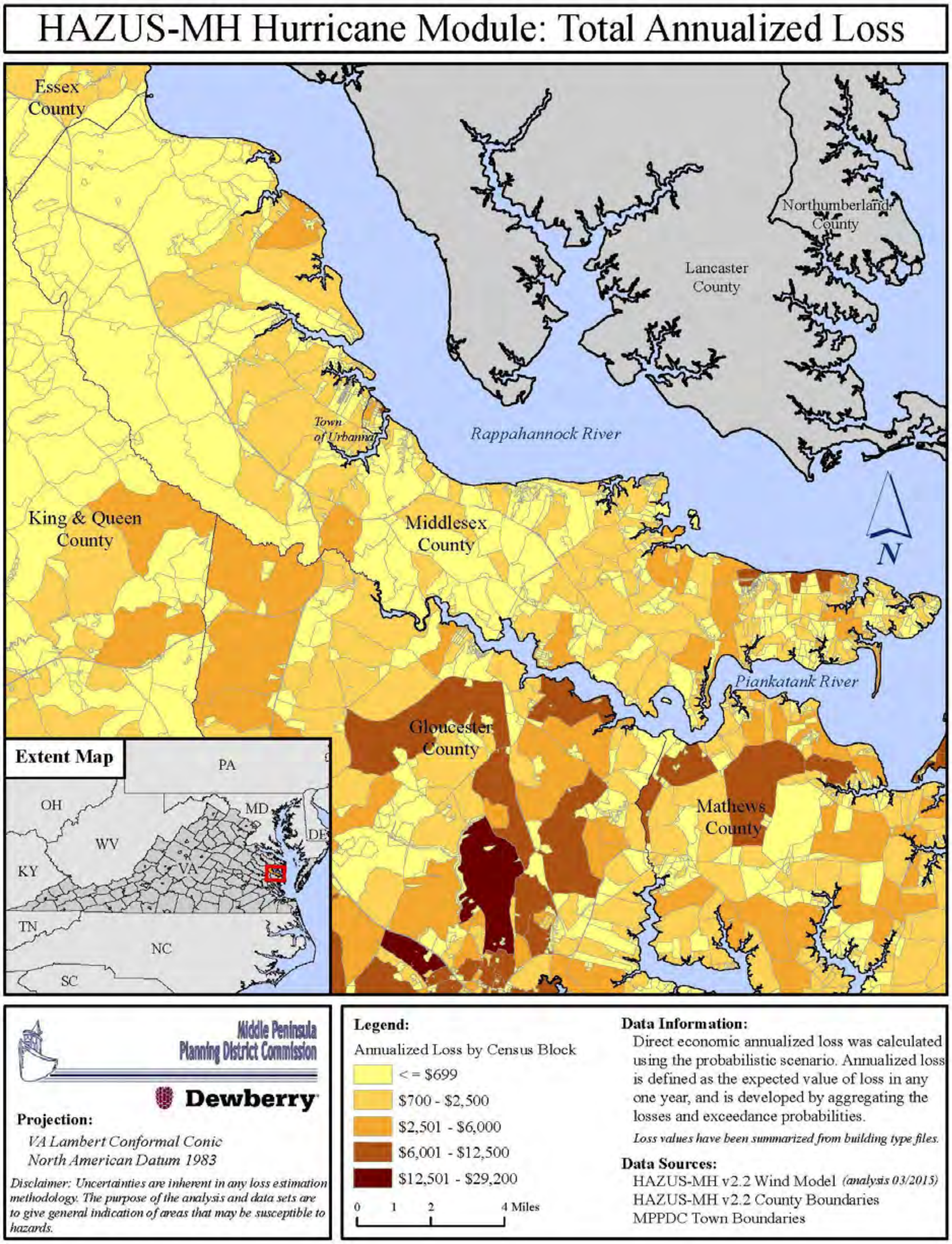
HAZUS-MH v2.2 Wind Model *(analysis 03/2015)*
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Hurricane Module: Total Annualized Loss
Caroline County
Town of Tappahannock
N
Richmond County
Essex County
Rappahannock River
Lancaster County
King & Queen County
Middlesex County
King William County
Hanover County
Extent Map
PA
OH
MD
DE
WV
VA
KY
TN
NC
SC
Town of West Point
Gloucester County
New Kent County
York River
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
<= $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 1 2 4 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Hurricane Module: Total Annualized Loss
Town of Tappahannock
Richmond County
Rappahannock River
Caroline County
Essex County
King & Queen County
King William County
Hanover County
New Kent County
Town of West Point
York River
N
Extent Map
PA
OH
MD
WV
DE
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
< = $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 1 2 4 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries



HAZUS-MH Hurricane Module: Total Annualized Loss
Middlesex County
Piankatank River
N
Mathews County
Gloucester County
Mobjack Bay
Chesapeake Bay
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
< = $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 0.5 1 2 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Hurricane Module: Total Annualized Loss
Essex County
Northumberland County
Lancaster County
Town of Urbanna
Rappahannock River
King & Queen County
Middlesex County
N
Piankatank River
Gloucester County
Mathews County
Extent Map
PA
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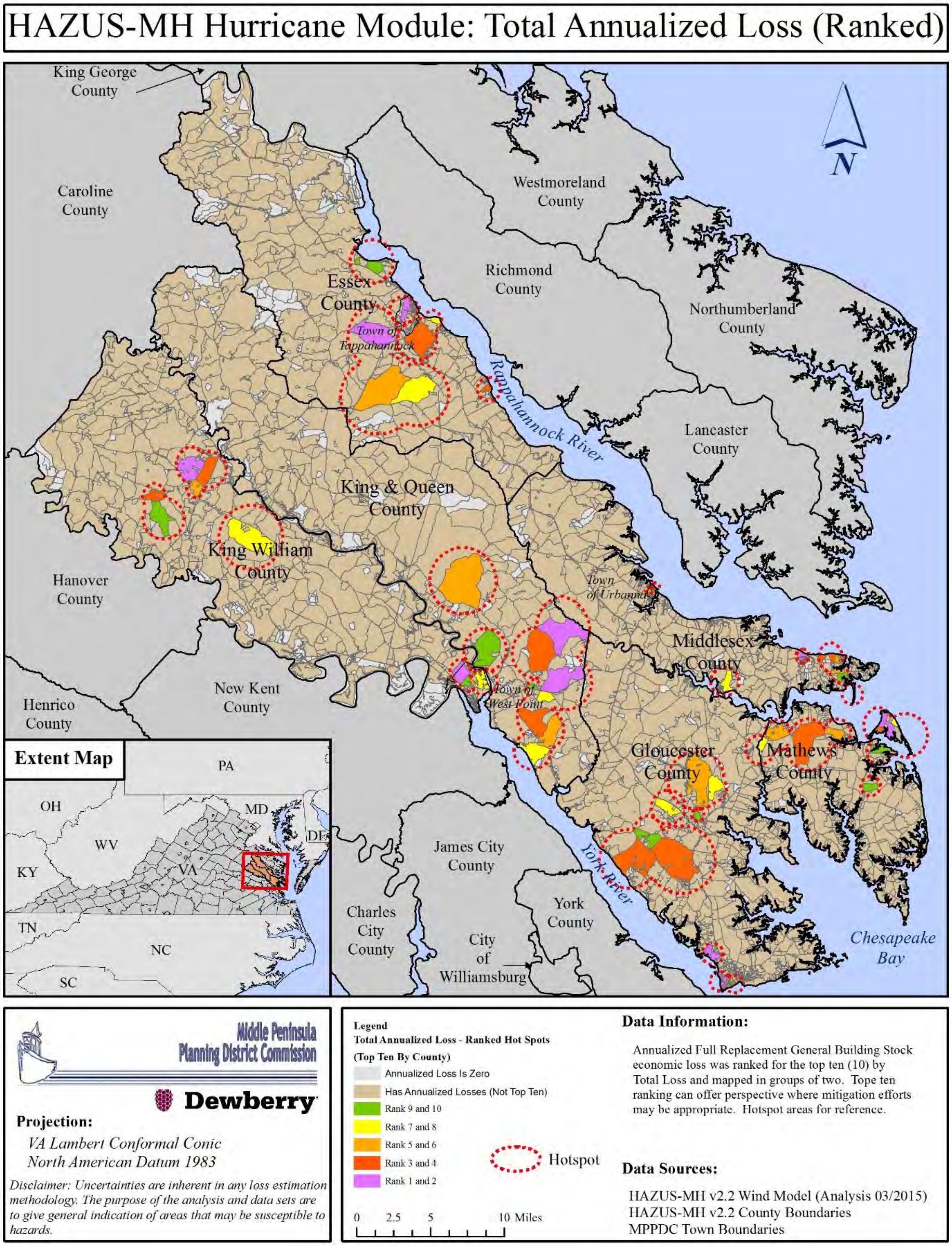
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Annualized Loss by Census Block
< = $699
$700 - $2,500
$2,501 - $6,000
$6,001 - $12,500
$12,501 - $29,200
0 1 2 4 Miles
Data Information:
Direct economic annualized loss was calculated using the probabilistic scenario. Annualized loss is defined as the expected value of loss in any one year, and is developed by aggregating the losses and exceedance probabilities.
Loss values have been summarized from building type files.
Data Sources:
HAZUS-MH v2.2 Wind Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Hurricane Module: Total Annualized Loss (Ranked)
King George County
Caroline County
Westmoreland County
Essex County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
Town of West Point
New Kent County
Henrico County
Gloucester County
Mathews County
James City County
York River
Charles City County
York County
City of Williamsburg
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend
Total Annualized Loss - Ranked Hot Spots
(Top Ten By County)
Annualized Loss Is Zero
Has Annualized Losses (Not Top Ten)
Rank 9 and 10
Rank 7 and 8
Rank 5 and 6
Rank 3 and 4
Rank 1 and 2
Hotspot
0 2.5 5 10 Miles
Data Information:
Annualized Full Replacement General Building Stock economic loss was ranked for the top ten (10) by Total Loss and mapped in groups of two. Tope ten ranking can offer perspective where mitigation efforts may be appropriate. Hotspot areas for reference.
Data Sources:
HAZUS-MH v2.2 Wind Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

Gloucester County accounts for almost 50% of the planning district's annualized losses. While losses are distributed throughout the County a few patterns of concentration can be identified. Many of the census blocks exhibiting annualized losses of $10,000 or greater appear to be on either side of State Route 17, clustered and radiating around Gloucester Courthouse. More specifically, from Gloucester Courthouse to the York River being bounded on the North by County 606 or Ark Road and bounded on the south by Nursery Lane, Haynes Pond, and Carter Creek – this area accounts for approximately $226,000 (or approximately 18%) of expected annualized damages. On the northern side of Gloucester Courthouse the area generally bounded in the west by Beech Swamp and Cow Creek in the east, and being traversed by Indian Road through the middle and extending north-east to the Piankatank River in the vicinity of Ferry Creek at Hell Neck – this area accounts for approximately $131,000 (or approximately 11%) of expected annualized damages. Finally, those census blocks having the greatest expected annualized losses are in the vicinity of Hayes and Gloucester Point along the York River where as much as $285,000-plus (or approximately 23% - and greater) of annualized damages are estimated.

Losses in Mathews County are also spread throughout the county with pockets of higher loss in the northern one-third of the county. Approximately $210,000 US Dollars (or 45%) of estimated annualized damages can be attributed to the northern one-third of the County; versus approximately $145,000 US Dollars (or 31%) in the center and $109,000 US Dollars (or 24%) in the southern one-third. Compared to Gloucester County, Mathews only has two (2) census blocks having expected annualized losses of $10,000 or greater, versus eighteen (18) such blocks in Gloucester. Mathews County accounts for approximately $464,000 or 18% of the total annualized losses in the planning district.

Middlesex County accounts for 15% of the total losses. The greatest concentration of estimated annualized loss is in the lower-eastern portion of the County; Gray's Point Road and south-eastward. This south-eastern portion of the County includes approximately $240,000 US Dollars (or 65%) of the estimated damages for the County. Other concentrations of estimated damages are distributed between Saluda, Urbanna and Water View. Urbanna accounts for approximately 6% of the annualized losses at approximately $24,000 US Dollars. Urbanna also includes two (2) census blocks within the top ten ranked blocks within the County accounting for $11,400 US Dollars or 48% of the losses in Urbanna.

Seven-percent of the total annualized damages ($168,260) for the region are attributed to King William County. King William exhibits four (4) primary areas where losses are concentrated. The first being the Town of West Point which can be attributed with thirty-one percent (31%) of the damages within the County having approximately $51,800 US Dollars of annualized loss. Next, there are two (2) areas near both Aylett and Manquin on the northern side of US 360 (Richmond-Tappahannock Highway). These two areas combined account for approximately $25,100 of annualized losses or fifteen-percent (15%). Last, the central portion of the County includes an area on either side of King William Road from West River Road in the north to Horse Landing Road in the south and accounting for roughly $7,500 US Dollars or four-percent (4%) of losses. The remainder of losses are distributed throughout the county with the greatest concentration of loss in the northwest quarter of the County. The Pamunkey Indian Reservation is estimated to have annualized loss values of approximately $1,100 US Dollars and the Mattaponi Reservation close to $830 US Dollars; combined the Indian Reservation losses account for approximately 1.2% of the losses throughout the County.

Essex County accounts for 7% of the total annualized losses. The greatest concentration of potential annualized wind damage exists in the central portion of the County – to include the Town of Tappahannock. This central area is traversed by three (3) of the primary roads being, US 360 (Richmond Highway), US 17 (Tidewater Trail) and Tappahannock Boulevard – running through the Town of Tappahannock. The combined annualized losses for this general area is approximately $71,000 US Dollars or forty-one percent (41%) of the losses within the County. The Town of Tappahannock accounts for twenty-percent (20%) of the damages in the County and an estimated $34,700 in annualized damages. Two pockets of development along the Rappahannock River (one south of Tappahannock and the other on the north side) represent clusters of potential damages. The area to the south of Tappahannock exists in the vicinity of River Landing Road in the north and Mill Swamp Road in the south having potential damages of $8,500 annually. The area north of Tappahannock is the vicinity near Woodside Country Club having potential damages of $7,300 annually.

King and Queen County has the lowest annualized loss values for the region, accounting for 4% of the total damages. Residential occupancy makes up the majority of the losses in the county. The southern one-third of the county, from roughly Dragon Run State Forest southward, has the greatest concentration of losses across the entire County accounting for nearly $59,500 or 60% of the losses. The remaining 40% of potential losses are distributed through the remainder of the county to the north and west with approximately $14,000 or 14% existing north of the Richmond-Tappahannock Highway and twenty-six percent (26%) distributed between the Richmond-Tappahannock Highway in the north to roughly Dragon Run State Forest in the south; note that this area includes locales such as Bruington, King and Queen Courthouse as well as Walkerton.

Building Damage

Hazus calculates expected damage percentages for each probabilistic return period. This represents the percentage of building square footage in each damage state. Five damage states have been specified in Hazus and are outlined in Table XX.

Table XX. Hazus-MH damage state thresholds.

Damage State	Qualitative Damage Description
None (Livable)	Little or no visible damage from the outside. No broken windows, or failed roof deck. Minimal loss of roof over, with no or very limited water penetration.
Minor (Livable)	Maximum of one broken window, door or garage door. Moderate roof cover loss that can be covered to prevent additional water entering the building. Marks or dents on wall requiring painting or patching for repair.
Moderate (Typically still livable)	Major roof cover damage, moderate window breakage. Minor roof sheathing failure. Some resulting damage to interior of building from water.
Severe (Typically non-livable but repairable)	Major window damage or roof sheathing loss. Major roof cover loss. Extensive damage to interior from water.
Destruction (Non-livable)	Complete roof failure and/or, failure of wall frame. Loss of more than 50% of roof sheathing.
Hazus-MH V2.2 Technical Manual	

Building Damage by Annual Chance Frequency (i.e., Multi-frequency Building Damages)

- **10 Year** - Hazus estimates that about 1 building will have minor damage. No buildings (0) are expected to be at least moderately damaged and no buildings (0) are expected to be completely destroyed during the 10-year event, or 10% annual chance.
- **20 Year** - Hazus estimates that about 7 buildings will have minor damage. No buildings (0) are expected to be at least moderately damaged and no buildings (0) are expected to be completely destroyed during the 20-year event, or 5% annual chance.
- **50 Year** - Hazus estimates that about 5 buildings will be at least moderately damaged and no buildings (0) are expected to be completely destroyed during the 50-year event, or 2% annual chance.
- **100 Year** - Hazus estimates that about 42 buildings will be at least moderately damaged and a single building (1) is expected to have severe damage – potentially another single (1) building may be expected to be completely destroyed during the 100-year event, or 1% annual chance.
- **200 Year** - Hazus estimates that about 131 buildings will be at least moderately damaged, approximately two (2) buildings are expected to be severely damaged, and four (4) buildings are expected to be completely destroyed during the 200-year event, or 0.5% annual chance.
- **500 Year** - Hazus estimates that about 740 buildings will be at least moderately damaged, approximately forty-one (41) buildings are expected to be severely damaged, and forty-seven (47) buildings are expected to be completely destroyed during the 500-year event, or 0.2% annual chance.
- **1000 Year** - Hazus estimates that about 1,523 buildings will be at least moderately damaged, approximately 127 buildings are expected to be severely damaged, and 133 buildings are expected to be completely destroyed during the 1,000-year event, or 0.1% annual chance.

Table XX and Appendix XX provide detailed information on the damage state percentages and number of buildings damaged for each of the probabilistic return periods.

The default data and parameters that Hazus utilizes are capable of producing crude estimates of losses (Table XX). Building damages, for each building stock category, are calculated based on the probabilities of the four different damage states for each wind building type as a function of peak gust wind speed. It should be noted that the results in Table XX are based solely on the modeled direct economic loss for the study region with the simulated hurricane activity for each of the independent return periods. It is possible, and not uncommon, to see reversals in damage state percentages, and there is no guarantee that the non-economic results will increase monotonically with return period.

Table XX. Building Damage by County.

Essex County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**100.00%**	**-**	**-**	**-**	**-**
20-year Event	**99.98%**	**0.02%**	**-**	**-**	**-**
50-year Event	**98.49%**	**1.46%**	**0.05%**	**-**	**-**
100-year Event	**99.97%**	**0.03%**	**-**	**-**	**-**
200-year Event	**98.82%**	**1.14%**	**0.04%**	**-**	**-**
500-year Event	**99.77%**	**0.23%**	**-**	**-**	**-**
1000-year Event	**94.26%**	**5.36%**	**0.35%**	**0.01%**	**0.01%**

King William County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**99.99%**	**0.01%**	**-**	**-**	**-**
20-year Event	**99.99%**	**0.01%**	**-**	**-**	**-**
50-year Event	**98.94%**	**1.04%**	**0.02%**	**-**	**-**
100-year Event	**99.93%**	**0.06%**	**-**	**-**	**-**
200-year Event	**98.67%**	**1.28%**	**0.05%**	**-**	**-**
500-year Event	**98.78%**	**1.15%**	**0.07%**	**-**	**-**
1000-year Event	**97.01%**	**2.79%**	**0.18%**	**-**	**0.01%**

Gloucester County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**100.00%**	**-**	**-**	**-**	**-**
20-year Event	**99.97%**	**0.03%**	**-**	**-**	**-**
50-year Event	**99.95%**	**0.05%**	**-**	**-**	**-**
100-year Event	**96.96%**	**2.86%**	**0.17%**	**-**	**-**
200-year Event	**92.95%**	**6.50%**	**0.53%**	**0.02%**	**0.01%**
500-year Event	**81.28%**	**15.90%**	**2.48%**	**0.18%**	**0.15%**
1000-year Event	**78.04%**	**18.14%**	**3.28%**	**0.30%**	**0.25%**

Mathews County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**100.00%**	**-**	**-**	**-**	**-**
20-year Event	**99.99%**	**0.01%**	**-**	**-**	**-**
50-year Event	**99.99%**	**0.01%**	**-**	**-**	**-**
100-year Event	**96.53%**	**3.31%**	**0.15%**	**-**	**-**
200-year Event	**95.89%**	**3.90%**	**0.20%**	**-**	**-**
500-year Event	**85.73%**	**12.67%**	**1.45%**	**0.075%**	**0.08%**
1000-year Event	**66.06%**	**26.15%**	**6.23%**	**0.81%**	**0.76%**

King & Queen County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**100.00%**	**-**	**-**	**-**	**-**
20-year Event	**100.00%**	**-**	**-**	**-**	**-**
50-year Event	**98.90%**	**1.08%**	**0.02%**	**-**	**-**
100-year Event	**99.88%**	**0.12%**	**-**	**-**	**-**
200-year Event	**97.79%**	**2.14%**	**0.07%**	**-**	**-**
500-year Event	**97.12%**	**2.73%**	**0.14%**	**-**	**-**
1000-year Event	**93.54%**	**6.03%**	**0.40%**	**0.01%**	**0.01%**

Middlesex County	Average Damage State (%)				
Return Period	None	Minor	Moderate	Severe	Destruction
10-year Event	**100.00%**	**-**	**-**	**-**	**-**
20-year Event	**99.99%**	**0.01%**	**-**	**-**	**-**
50-year Event	**99.90%**	**0.10%**	**-**	**-**	**-**
100-year Event	**98.70%**	**1.26%**	**0.04%**	**-**	**-**
200-year Event	**94.75%**	**4.95%**	**0.29%**	**-**	**0.01%**
500-year Event	**83.23%**	**14.25%**	**2.15%**	**0.17%**	**0.20%**
1000-year Event	**73.66%**	**20.86%**	**4.39%**	**0.53%**	**0.56%**

Debris Generation

Hazus estimates the amount of debris that will be generated by a hurricane. The model breaks the debris into three general categories: Brick/Wood, Reinforced Concrete/Steel, and Trees. Tree debris makes up the majority of tonnage generated in the hurricane analysis. Brick and wood debris makes up the remainder and a very small percentage (0.01%) associated with Concrete and Steel; i.e., not shown in Table. Table XX summarizes, by return period, the total generated debris by Type.

Table XX. Hurricane debris generation.

Return Period	Total Debris (tons)	Tree Debris (tons)	% Tree Debris	Brick & Wood (tons)	% Brick and Wood
10-year Event	84	84	100%	0	0.00%
20-year Event	31,872	31,867	99.98%	5	0.02%
50-year Event	155,202	154,721	99.69%	481	0.31%
100-year Event	136,004	134,162	98.65%	1,842	1.35%
200-year Event	322,936	318,532	98.64%	4,400	1.36%
500-year Event	376,818	363,772	96.54%	12,930	3.43%
1000-year Event	705,647	682,410	96.71%	22,801	3.23%

Essential Facilities

Essential facilities, including medical care facilities, emergency response facilities and schools, are those vital to emergency response and recovery following a disaster. School buildings are included in this category because of the key role they often play in sheltering people displaced from damaged homes. Generally there are very few of each type of essential facilities in a census tract, making it easier to obtain site-specific information for each facility. Thus, damage and loss-of-function are evaluated on a building-by-building basis for this class of structures; even through the uncertainty in each such estimate is large[6].

The Hazus essential facilities database includes default data for Medical Care Facilities, Emergency Response Facilities (fire stations, polices stations, EOCs) and schools. Table XX shows the functionality, by return period for each essential facility type. The region's essential facilities are able to remain functional for the 10-, 20-, 50-, and 100-yr recurrence interval. Functionality begins to decline at the 100-year event. All of the facilities have zero functionality during a 1000-year event.

Table XX. Essential facility functionality for specified return periods.

[6] Multi-hazard Loss Estimation Methodology Hurricane Model User Manual, HAZUS-MH V2.2, Chapter 1: Introduction, 1-6

Return Period	Fire Stations	Hospitals	Police Stations	Schools
10-year Event	100%	100%	100%	100%
20-year Event	100%	100%	100%	100%
50-year Event	100%	100%	100%	100%
100-year Event	90%	100%	100%	92%
200-year Event	70%	100%	91%	84%
500-year Event	50%	62%	55%	40%
1000-year Event	0%	0%	0%	0%

Potential Mitigation Actions:

The potential mitigation actions noted are those that are Hazus-specific and would benefit refinement of Hazus analyses.

- ☐ Perform Hazus analyses based on the same data resources used to develop the inundation areas mapped in the report submitted to the Virginia General Assembly in January 2013 titled – RECURRENT FLOODING STUDY FOR TIDEWATER VIRGINIA by the Virginia Institute of Marine Science, Center for Coastal Resources Management at the College of William & Mary. This study appears to include the most widely accepted Sea Level Rise plus Storm Surge Scenario facing coastal Virginia. It would therefore be appropriate to consider 1.) The creation of depth grids from the study data and then 2.) Hazus Risk Assessment. It would also be beneficial to incorporate elements of the design storm into a combined Hazus Flood and Hurricane Scenario - in this manner benefits of the combined methodology can be realized – which includes methods to guard against over-counting or double-counting losses by simply adding damages from each respective Hazus model.
- ☐ Perform Hurricane analysis for a known and historic storm that affected the MPPDC area for comparative purposes.
- ☐ Refine and update data sets for GBS and essential facilities.
    - Improvements in the future should aim to further refine the building stock. Notably, one improvement should include adding any new development that may not have been in the land use/land cover data; e.g., new housing developments, new construction, etc…
    - Perform localized building-level assessments in known areas of loss and or areas subject to likely losses.

Sea Level Rise Analysis:

The Hazus Flood Model analyzes both riverine and coastal flood hazards. Flood hazard within Hazus is defined by depth of flooding. Other contributing factors of damage include the duration and velocity of water in the floodplain. Other hazards associated with flooding that may contribute to flood losses include channel erosion and migration, sediment deposition, bridge scour and the impact of flood-born debris. The Hazus Flood Model allows users to estimate flood losses primarily due to flood depth to the general building stock (GBS). While velocity is also considered, it is not a separate input parameter and is accounted within depth-damage functions (i.e., expected percent damage given an expected depth) for census blocks that are defined as either coastal or riverine influenced.

Flood-specific modeling was performed in this Plan revision to determine annualized flood loss however it is important to note that the Sea Level Rise analyses while similar is not 100% the same as the multi-frequency analyses performed and presented in the Flood Section; see Section XX – Flood Analysis. While this section does not intend to fully explain detailed elements of coastal flood modeling, a basic amount of information is offered to differentiate between the two report sections.

Coastal flood modeling typically includes identifying baseline tidal water levels and then computing additions or increases to water surface levels from various natural forces such as storm surge effects (i.e., water level increases as the result of a storm pushing landward) as well as other wave-related effects such as increased wave heights and the run-up of waves over the land as waves crash. Other factors of coastal storms play a part in estimating increased water surface levels such as shoreline and/or dune erosion. Consequently, each of the scenarios presented in Section XX – Flood Analysis, includes depth grids produced from modeling that takes into account increases to water surface levels from the various forces typical of coastal storm events – a.k.a. Storm Surge.

In contrast, the Hazus analysis performed for the Sea Level Rise scenarios (this section) DO NOT include the use of depth grids that include storm surge. Rather, this Sea Level Rise section uses depth grids that 1.) Are depths from the baseline tidal water levels (Mean Higher High Water or MHHW) and 2.) Includes the addition of six-feet of water – as if the new baseline tidal water level were increased by simply adding more water into the same 'bathtub' - as it were. The two depth grids run through Hazus represent these two aforementioned scenarios developed by NOAA - Office for Coastal Management for the on-line application known as Sea Level Rise and Coastal Flooding Impacts v2.0.

Multiple resources were consulted for data that would support Sea Level Rise (SLR) risk assessments across the Middle Peninsula planning district. Primary focus was placed on the existence of Hazus-ready inputs, which would include the existence and availability of depth grids. Depth grids are able to be directly imported into the Hazus Flood model and eliminates the need to pre-process other modeling or Geographic Information Systems (GIS) data. Generally-speaking, the creation of depth grids require GIS data that represents an estimated water surface along with an associated ground surface. Thereafter, the difference between the two surfaces represents the estimated depth of flooding for a given location; i.e., water elevation less ground elevation equals depth; see Depth Grid Graphic in the Flood Analysis Section on Page XX.

Considering the SLR resources researched, depth grids were only available from NOAA's Office for Coastal Management (see http://coast.noaa.gov/slr/) as part of its Sea Level Rise and Coastal Flooding Impacts v2.0 Application. An additional resource was available from VIMS – The Virginia Institute of Marine Science at the College of William & Mary, however the resource is NOT depth grids but rather a GIS mapping product that delineates the inundation areas of 1.5 Feet of Sea Level Rise plus an additional 3-Feet of storm surge.

To exemplify the various resources consulted in search of the priority SLR depth grids, the following list offers an itemization and brief description(s):

- **US EPA -** Titus, J.G., D.E. Hudgens, C.Hershner, J.M. Kassakian, P.R. Penumalli , M. Berman, and W.H. Nuckols. 2010. "Virginia". In James G. Titus and Daniel Hudgens (editors). *The Likelihood of Shore Protection along the Atlantic Coast of the United States. Volume 1: Mid-Atlantic.* Report to the U.S. Environmental Protection Agency. Washington, D.C.
    - [The] *"…study develops maps that distinguish the areas likely to be protected from erosion and inundation as the sea rises from those areas that are likely to be left to retreat naturally assuming that current policies and economics trends continue*." – page 709.
    - The study claims to be *"…literally a "first approximation" of the likelihood of shore protection*." – page 710.
    - The study report includes a variety of tables culminating in and seeking to describe AREA OF LAND VULNERABLE TO SEA LEVEL RISE. However, a number of MPPDC jurisdictions are void of results with the authors citing the following:
        - "*Value omitted because the topographic information Titus and Wang used for this jurisdiction had poor vertical resolution*." – page 777 (Note [e] of TABLE 8-10).
    - The study includes GIS data that distinguishes between three (3) primary land classes; Tidal Wetlands, Tidal Open Water and Uplands. An overlay Digital Elevation Model (DEM) is also included that indicates a series of elevation bands at half-foot elevation intervals ranging from zero-feet (0.0 Ft.) to three-feet (3.0 Ft.) above the delineation of Tidal Wetlands.
    - The study includes additional analyses in cooperation with Virginia Institute of Marine Science (VIMS) and mapping that characterizes the likelihood of shoreline protection; see VIMS below.
    - No depth grid data available.
- **VIMS** – Virginia Institute of Marine Science, College of William & Mary.
    - RECURRENT FLOODING STUDY FOR TIDEWATER VIRGINIA. Report submitted to the Virginia General Assembly. January 2013.
        - The study, in-part, developed mapping of areas affected (i.e., expected inundation) by:
            - Projected Sea Level Rise of 1.5 Feet with…
            - Projected Storm Surge of an additional 3.0 Feet
        - The study suggests that the scenario elements noted above (SLR of 1.5 feet and Surge of +3 feet) "…*represent very moderate assumptions*…" and that the values are "…*within the range*…" of best available forecasts; - page 8.
        - Inquiry also revealed that <u>depth grid data was not produced</u> as part of the study.
    - Comprehensive Coastal Resource Management Tool
        - No depth grids.
- **US Fish and Wildlife Services (USFWS) (and partners)** – SLAMM View Application (Sea Level Affecting Marshes Model)
    - No depth grids.
- **Climate Central** – Surging Seas Application (Sea Level Affecting Marshes Model)
    - No depth grids.
- **The Nature Conservancy (and partners) -** Coastal Resilience Tool

- o Application utilizes the same data used in the National Oceanic and Atmospheric Administration (NOAA) Sea Level Rise and Coastal Flooding Impacts v2.0 Application; see below (NOAA – Office for Coastal Management).
  - o Application does not cover Virginia.
- **NOAA** - Office for Coastal Management
  - o Sea Level Rise and Coastal Flooding Impacts v2.0
    - Sea Level Rise based on Mean Higher High Water (MHHW) conditions and the addition of incremental 1-foot SLR increases to include Plus 1-Foot to Plus 6-Foot.
    - Depth grids available.
    - Depth grids obtained and used for this Plan; this Plan utilizes the Base Scenario of Mean Higher High Water (MHHW) conditions and also the Plus 6-Foot Scenario. Other scenarios were not utilized; namely the Plus 1-Foot, Plus 2-Foot, Plus 3-Foot, Plus 4-Foot and Plus 5-Foot.

Building Stock

The same dasymetric building stock (i.e., square-footage inventory of buildings) that was utilized for the Flood Analysis was also used for Sea Level Rise.

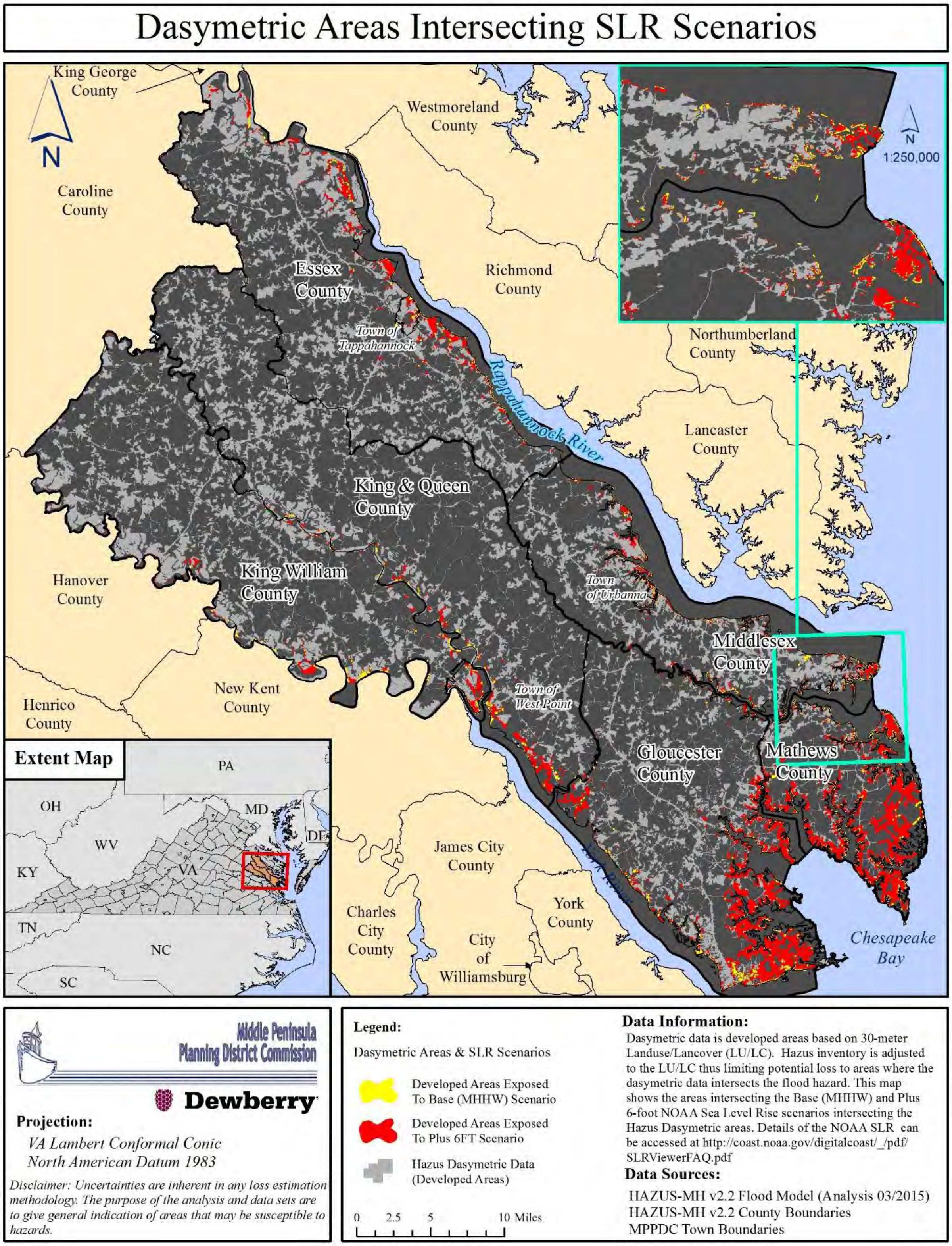
All building inventory statistics (i.e., building stock exposure by county or general building type) that were used for the Sea Level Rise Hazus scenarios are the same as defined in the Flood Analysis section. Please see Flood Analysis, Table XX. Building stock exposure for general occupancies by county and Table XX. Building stock exposure for general building type by county.

Dynamics of exposure (and also loss) are dependent on a number of variables. A key variable, for example, includes the spatial accuracy (30-meter) of the land-use/land-cover data used to create the developed areas of the dasymetric building stock inventory. Another key variable includes the spatial accuracy (i.e., horizontal accuracy) and also the vertical accuracy of the topographic data used to delineate flood inundation areas. Therefore, detailed site analyses may be appropriate and necessary to further understand local dynamics. However, noting the regional nature of the risk assessments performed, a few tables for reference are provided of the Sea Level Rise scenarios to help better understand the dasymetric building stock that is 1.) Potentially exposed and 2.) May experience potential loss. First, acreage of developed land intersecting the SLR scenarios is captured in Table XX below:

Table XX – Acreage of Dasymetric Areas (30m Developed Areas) intersecting SLR Scenarios.

Base (MHHW) Sea Level Rise Scenario			Plus 6-Feet Sea Level Rise Scenario		
Rank MHHW	County	Acreage of Dasymetric Developed Areas	Rank Plus 6FT	County	Acreage of Dasymetric Developed Areas
1	Mathews	105	1	Mathews	4,817
2	Middlesex	96	2	Gloucester	4,155
3	Gloucester	63	3	Essex	837
4	King William	30	4	Middlesex	585
5	King and Queen	28	5	King and Queen	454
6	Essex	22	6	King William	393
Total		**344**		**Total**	**11,242**

Figure XX - Dasymetric Areas Intersecting SLR Scenarios (next page) shows the dasymetric developed areas intersecting both the Base (MHHW) and the Plus 6-Foot Scenario's. The map also shows an example area in closer detail (scale of 1:250,000).



Next, Table XX and Table XX show the Total Exposure In the Flood Hazard Area of the Hazus Dasymetric Data by General Occupancy Type for both of the Sea Level Rise scenarios.

Table XX. Exposed General Occupancy by County – Sea Level Rise Base Scenario (MHHW).

County	Residential	Commercial	Industrial	Agriculture	Religion	Govt.	Education	Total Exposure
Middlesex	$24,347	$1,121	$303	$32	$257	$15	$17	$26,092
Mathews	$19,910	$1,199	$285	$132	$95	$36	$45	$21,702
Gloucester	$17,251	$1,793	$415	$40	$176	$19	$83	$19,777
Essex	$5,553	$516	$75	$14	$34	$0	$88	$6,280
King William	$4,065	$409	$58	$13	$2	$1	$0	$4,549
King and Queen	$2,361	$1	$477	$0	$0	$0	$-0	$2,840
Total	$73,488	$5,040	$1,613	$231	$565	$70	$233	$81,241
								All values in Thousands of Dollars

Table XX. Exposed General Occupancy by County – Sea Level Rise Plus 6FT Scenario.

County	Residential	Commercial	Industrial	Agriculture	Religion	Govt.	Education	Total Exposure
Gloucester	$590,313	$72,485	$17,186	$2,934	$8,721	$653	$14,805	$707,095
Mathews	$601,918	$25,535	$15,695	$4,401	$4,251	$958	$724	$653,482
Middlesex	$156,312	$8,602	$2,355	$193	$1,800	$167	$160	$169,587
Essex	$87,087	$12,067	$4,404	$559	$221	$68	$371	$104,776
King William	$61,575	$13,675	$1,950	$70	$1,369	$426	$807	$79,873
King and Queen	$33,313	$23	$1,358	$0	$10	$4	$-0	$34,708
Total	$1,530,517	$132,388	$42,948	$8,156	$16,372	$2,275	$16,867	$1,749,521
								All values in Thousands of Dollars

Users are encouraged to consider that while one County may have a greater area of developed land intersecting the SLR flood inundation, the square-footage and/or value of structures within the developed areas may have very different value estimates. Consequently, it can be seen that Middlesex County has a great deal of development in close proximity to the Base (MHHW) Scenario flood hazard – particularly in the Residential category ($24.3 Million). However, as was mentioned earlier, the resolution or spatial accuracy of the 30-meter land-use/land-cover data used to create the dasymetric developed areas does not take into account elevation. There are areas within the District that have development on high ground near flooding sources. Middlesex County has a number of these areas. This combination in conjunction with higher residential exposure ($24.3 Million) shows Middlesex as more susceptible to the Base (MHHW) Sea Level Rise Scenario.

In contrast, development patterns in the eastern-most portion of Middlesex as well as the two most eastern counties of Gloucester and Mathews, exhibit development that is set-back away from areas of open and tidal waters – thus exhibiting less exposure to the Base (MHHW) SLR Scenario. However, as water levels rise, as would be the case of the Plus 6-Foot Scenario, the development along the low-lying fringes of the coastal plain become more susceptible to the flood hazard and therefore includes a greater proportion of building inventory exposed to the potential rising water levels.

Sea Level Rise – Hazus Level 1 Methodology General Building Stock Loss Estimation

Losses are presented similar to the Flood Analysis however, only the combined Total losses of all building categories are presented in an effort to keep the results as simple as possible for relative comparison to the more detailed multi-frequency flood analysis. To reiterate, the multi-frequency analysis (Section XX – Flood Analysis) DOES include water surface levels that take into account storm surge.

Hazus Level 1 flood model losses for the Middle Peninsula planning district from the Base Sea Level Rise scenario (MHHW) are approximately $10.2 Million US Dollars and the Plus 6-Foot of Sea Level Rise are approximately $283.5 Million US Dollars which is a 96% increase in the expected Total damages. Property or "capital stock" losses of the Base Sea Level Rise accounts for all of the expected loss ($10.2 Million) whereas the Plus 6-Foot of Sea Level Rise scenario is estimated to be approximately $283.1 Million or 99.86% of the damages which includes the values for building, content, and inventory. Business interruption of the Plus 6-Foot of Sea Level Rise scenario accounts for $386,000 US Dollars (0.14%) of the losses and includes relocation, income, rental and wage costs.

Table XX and Table XX illustrate the expected losses broken down by county from the Sea Level Rise scenarios. Middlesex County, having the highest level of estimated exposure ($26.092 Million US Dollars) within the Base Sea Level Rise inundation area, also has the highest loss from the Base Sea Level Rise scenario at approximately $3.02 Million US Dollars which accounts for 30% of the total losses for the Middle Peninsula[7]. Gloucester County is attributed with 27% of total losses at approximately $2.76 Million, and Mathews County has losses of approximately $2.5 Million or 25% of the total – followed by King William (9%), Essex (7%) and last King and Queen (2%). The relatively higher loss percentages attributed to Middlesex, Gloucester and Mathews counties suggests that the distribution of development at-risk includes the low-lying coastal plains along the Chesapeake and Mobjack Bays as well as the York River.

The Plus 6-Foot of Sea Level Rise scenario also shows the greater combined losses in the down-east area however, Gloucester and Mathews account for the greatest combined losses (75%). Gloucester County has the highest loss from the Plus 6-Foot of Sea Level Rise scenario at approximately $116.6 Million US Dollars, accounting for 41% of the total losses for the Middle Peninsula. The Plus 6-Foot of Sea Level Rise scenario shows Mathews County at approximately $96.9 Million and ranked second (34% of Total) – followed by Middlesex County at approximately $29.2 Million (10% of Total) – and then King William (6%), Essex (6%) and last King and Queen (2%). Again, the relatively higher loss percentages attributed to Gloucester and Mathews counties suggests that the distribution of development at-risk includes the low-lying coastal plains along the Chesapeake and Mobjack Bays as well as the York River. Figure XX exemplifies the differences between the inundation extents of the SLR Base and Plus 6-Foot

[7] Readers are reminded due to the regional nature of the analysis, detailed site analyses may be entirely appropriate and necessary to fully understand local dynamics. Especially in areas where development is in close proximity to flooding sources and also marked topographic elevation changes.

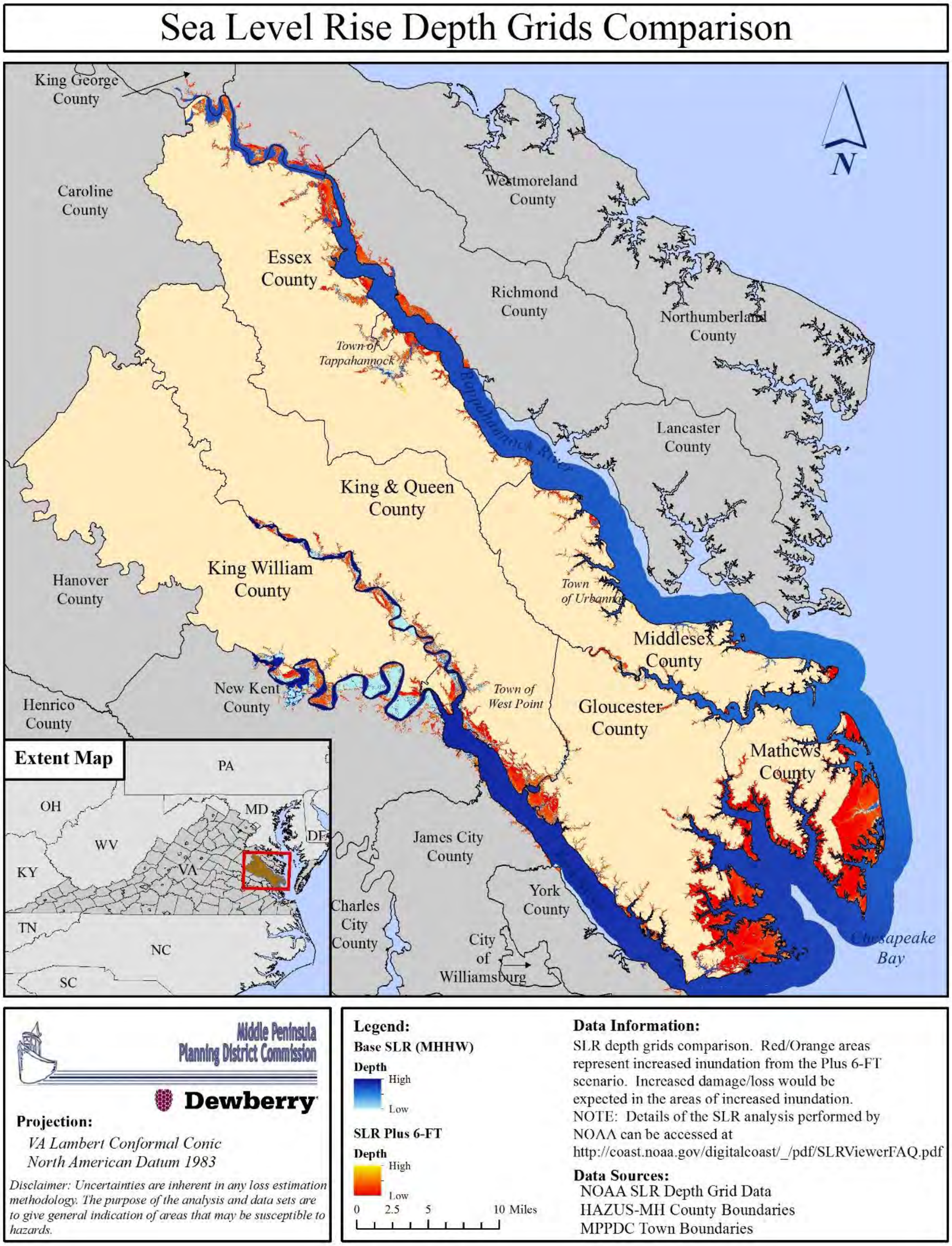
scenarios; the mapping of the depth grids represented by red/orange areas are the increased inundation areas of the Plus 6-Foot scenario. Development in these areas would be susceptible to greater potential losses.

Table XX. County based Hazus loss for both Pre- and Post-FIRM – Sea Level Rise Base.

County	Building	Content	Inventory	Relocation	Income	Rental	Wage	Total Loss
Middlesex	$1,805	$1,209	$1	$0	$0	$0	$0	$3,015
Gloucester	$1,638	$1,120	$2	$0	$0	$0	$0	$2,760
Mathews	$1,494	$1,002	$0	$0	$0	$0	$0	$2,496
King William	$532	$406	$0	$0	$0	$0	$0	$938
Essex	$391	$331	$0	$0	$0	$0	$0	$722
King and Queen	$150	$97	$7	$0	$0	$0	$0	$254
Total	$6,010	$4,165	$10	$0	$0	$0	$0	$10,185
All values in Thousands of Dollars								

Table XX. County based Hazus loss for both Pre- and Post-FIRM – Sea Level Rise Plus 6FT.

County	Building	Content	Inventory	Relocation	Income	Rental	Wage	Total Loss
Gloucester	$63,431	$52,381	$607	$70	$38	$5	$93	$116,625
Mathews	$55,754	$40,566	$492	$73	$8	$7	$18	$96,918
Middlesex	$16,772	$12,342	$66	$13	$5	$0	$6	$29,204
King William	$8,561	$9,603	$89	$2	$12	$0	$22	$18,289
Essex	$8,202	$7,511	$140	$8	$1	$0	$4	$15,866
King and Queen	$3,999	$2,561	$61	$1	$0	$0	$0	$6,622
Total	$156,719	$124,964	$1,455	$167	$64	$12	$143	$283,524
All values in Thousands of Dollars								

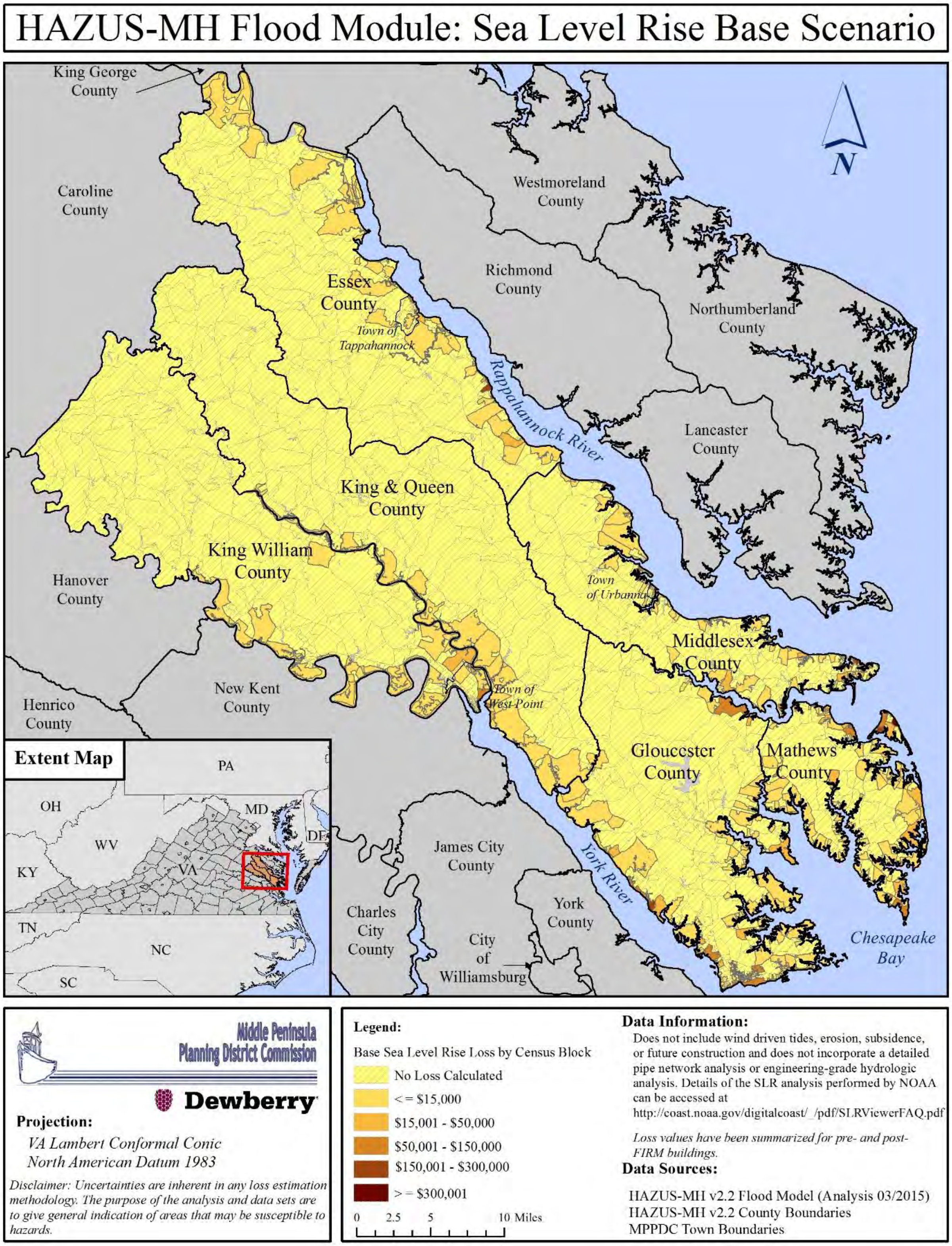

Sea Level Rise Depth Grids Comparison
King George County
Caroline County
Essex County
Westmoreland County
Richmond County
Northumberland County
Town of Tappahannock
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Town of West Point
Gloucester County
Henrico County
Mathews County
James City County
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Base SLR (MHHW)
Depth
High
Low
SLR Plus 6-FT
Depth
High
Low
0 2.5 5 10 Miles
Data Information:
SLR depth grids comparison. Red/Orange areas represent increased inundation from the Plus 6-FT scenario. Increased damage/loss would be expected in the areas of increased inundation.
NOTE: Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Data Sources:
NOAA SLR Depth Grid Data
HAZUS-MH County Boundaries
MPPDC Town Boundaries

Figures XX through XX on the following pages show the total losses for the planning district for both SLR scenarios, Ranking of the top ten loss of census blocks (Ranked within each respective County) and last, a map showing the comparative differences in the ranked hot spot areas representing those areas throughout the MPPDC Region that may require mitigation measures. County-specific maps are shown of the Plus 6-Foot SLR scenario.

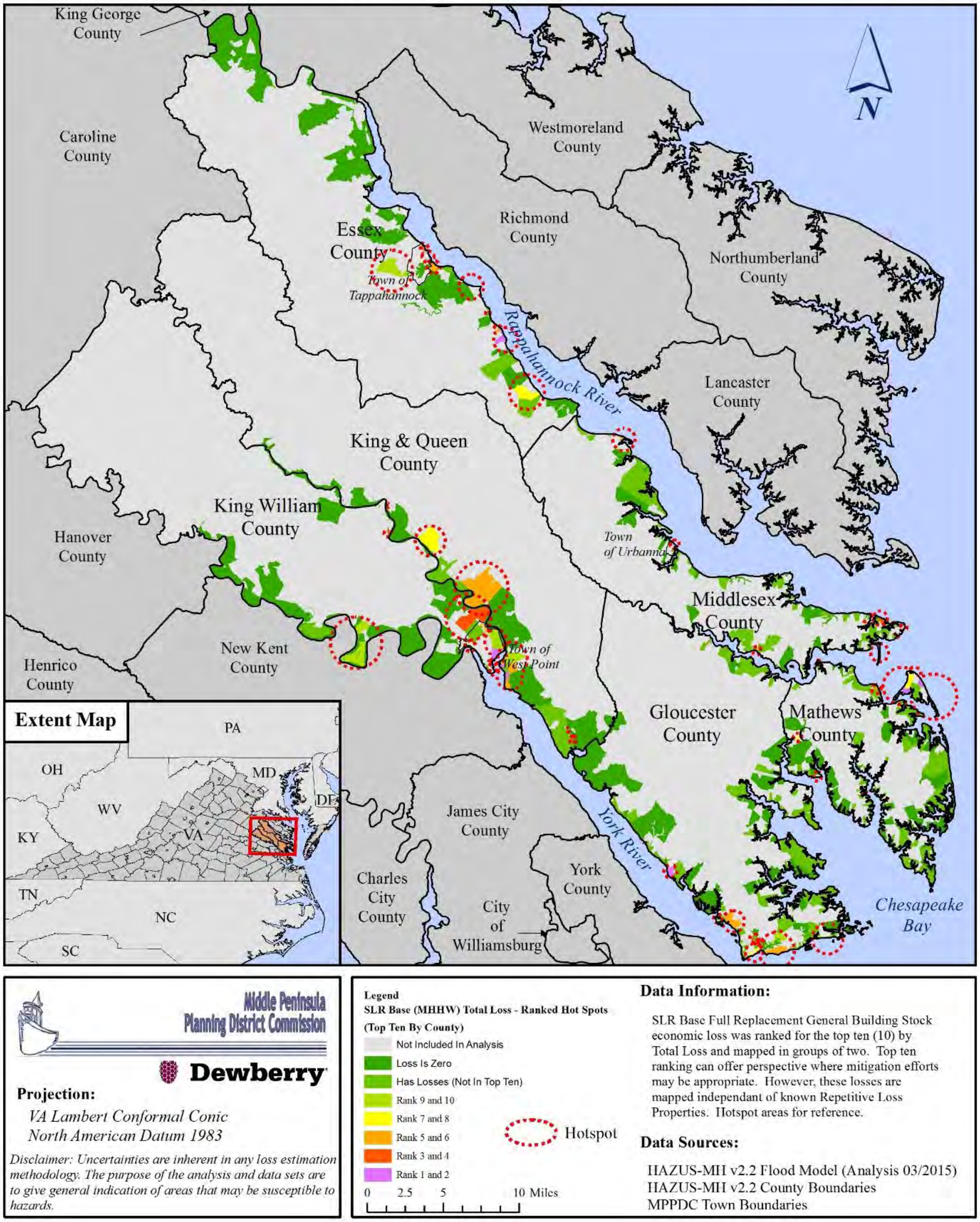
Again, users of these maps are reminded that the scenarios shown in the following maps DO NOT include increases to water surface levels from the various natural forces typical of coastal storm events (e.g., Storm Surge). The following results are intended to offer perspective on potential damage/loss in the event that the baseline water surface were to increase by 6-Feet.

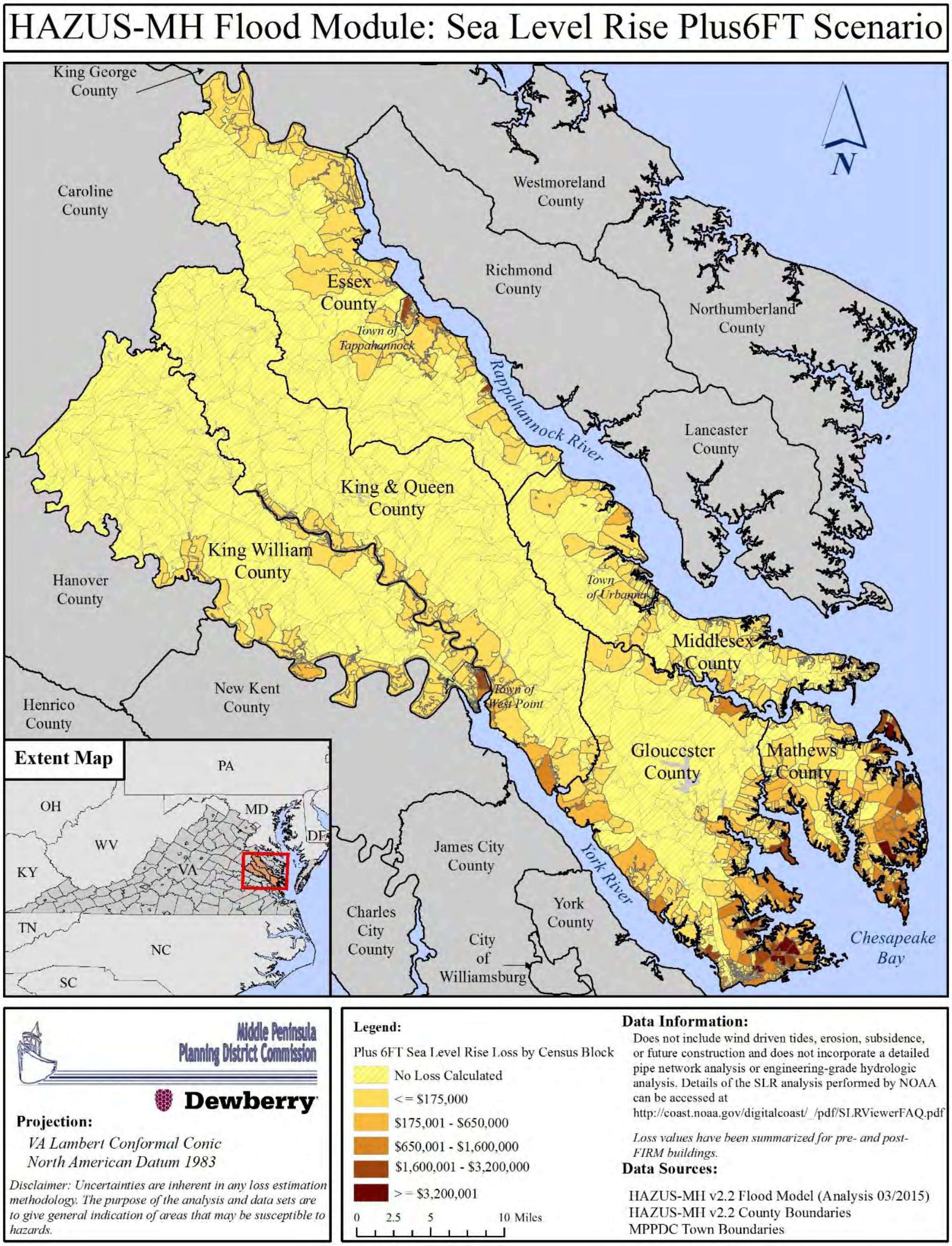
Another factor to consider while viewing Maps and Tables is that the Base Scenario is essentially the average of the highest tide that is experienced on a daily-basis over a long period of time. Typical there are two high tides in a given day, the MHHW represents the mean (or average) of the higher of the two tides as recorded over a period of record. The definition as provided by NOAA – Tides & Currents states, "The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, comparison of simultaneous observations with a control tide station is made in order to derive the equivalent datum of the National Tidal Datum Epoch."[8]

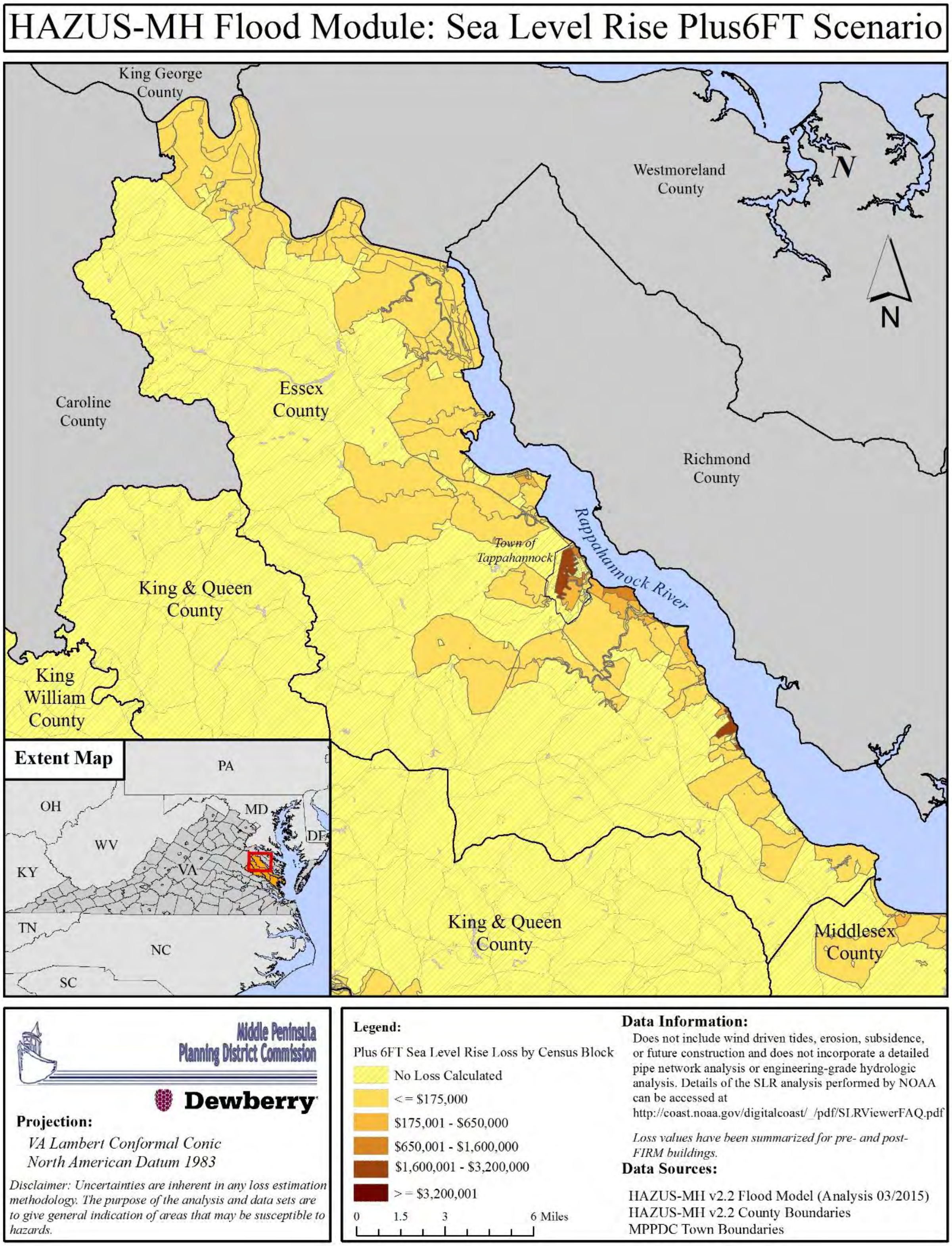
[8] NOAA – Tides & Currents (http://tidesandcurrents.noaa.gov/datum_options.html), accessed April 22, 2015.

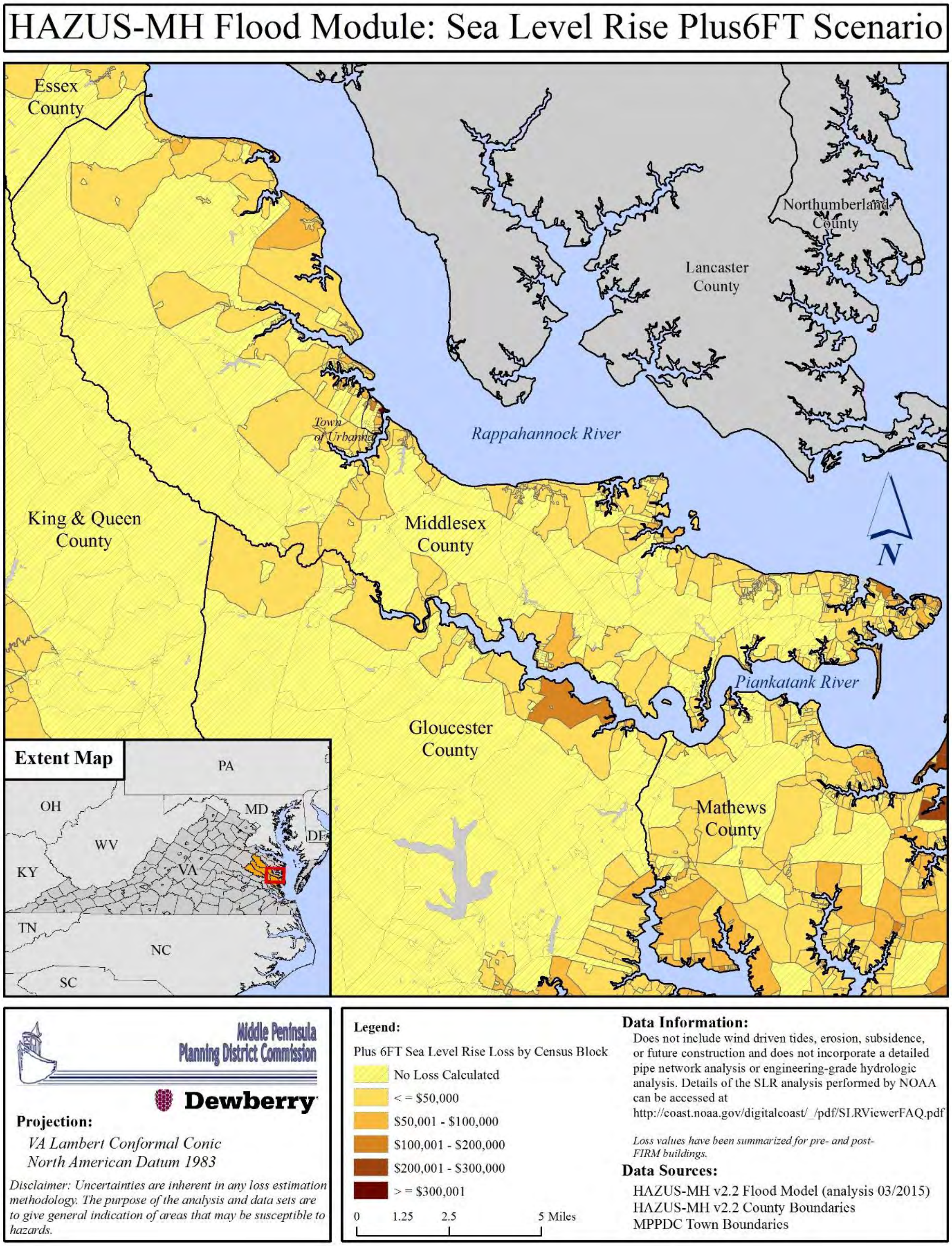

HAZUS-MH Flood Module: Sea Level Rise Base Scenario
King George County
Caroline County
Westmoreland County
Essex County
Town of Tappahannock
Richmond County
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Henrico County
Town of West Point
Gloucester County
Mathews County
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Base Sea Level Rise Loss by Census Block
No Loss Calculated
<= $15,000
$15,001 - $50,000
$50,001 - $150,000
$150,001 - $300,000
>= $300,001
0 2.5 5 10 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

Sea Level Rise Base Scenario (MHHW): Total Loss (Ranked)

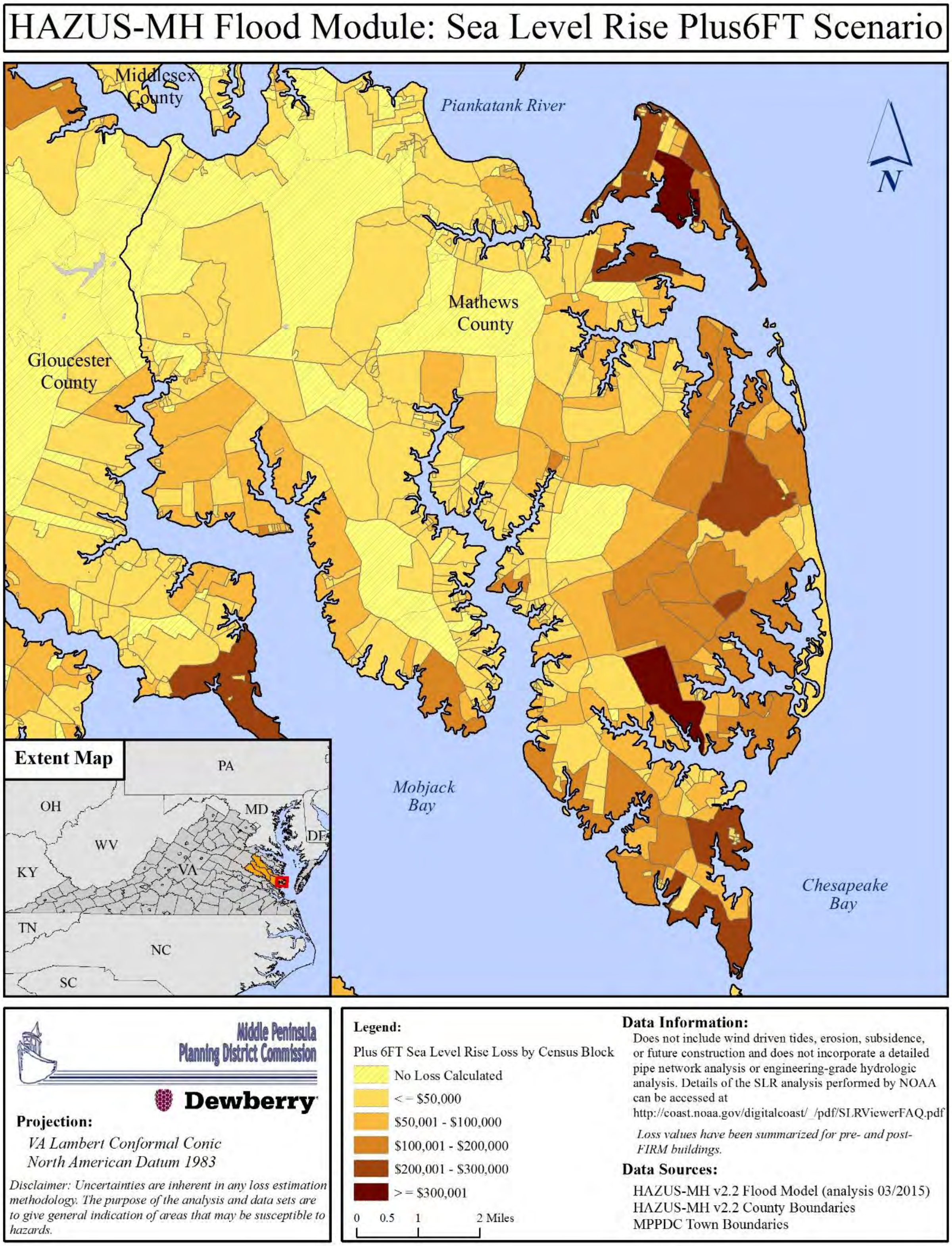


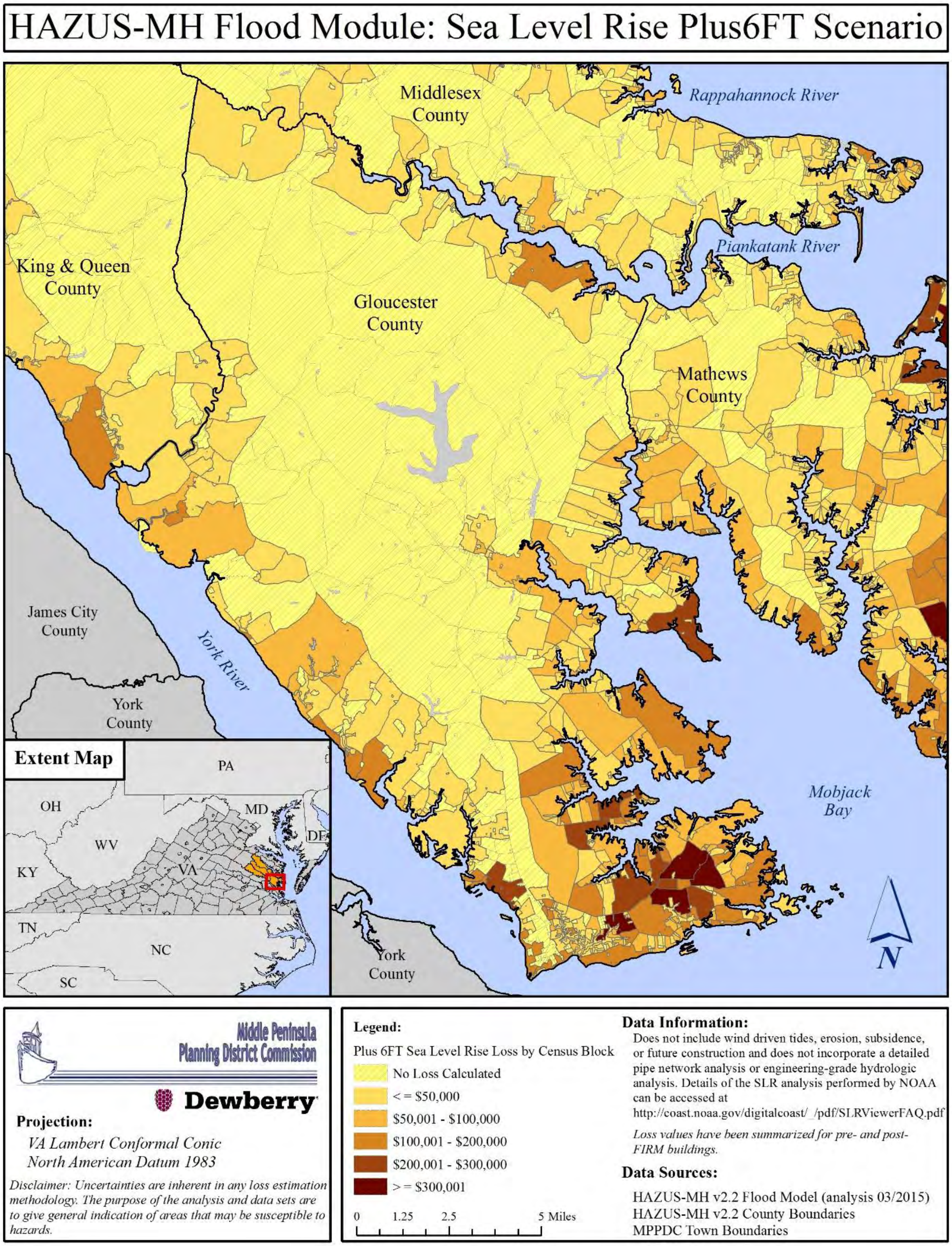

HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
King George County
Caroline County
Westmoreland County
Essex County
Town of Tappahannock
Richmond County
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
Henrico County
New Kent County
Town of West Point
Gloucester County
Mathews County
James City County
York River
Charles City County
City of Williamsburg
York County
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
<= $175,000
$175,001 - $650,000
$650,001 - $1,600,000
$1,600,001 - $3,200,000
>= $3,200,001
0 2.5 5 10 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
King George County
Westmoreland County
Caroline County
Essex County
Richmond County
Town of Tappahannock
Rappahannock River
King & Queen County
King William County
King & Queen County
Middlesex County
N
Extent Map
PA
OH
MD
DE
WV
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
<= $175,000
$175,001 - $650,000
$650,001 - $1,600,000
$1,600,001 - $3,200,000
>= $3,200,001
0 1.5 3 6 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries



HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
Essex County
Northumberland County
Lancaster County
Town of Urbanna
Rappahannock River
King & Queen County
Middlesex County
N
Piankatank River
Gloucester County
Mathews County
Extent Map
PA
OH
MD
DE
WV
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1.25 2.5 5 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
Middlesex County
Piankatank River
N
Mathews County
Gloucester County
Mobjack Bay
Chesapeake Bay
Extent Map
PA
OH
MD
DE
WV
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 0.5 1 2 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
Middlesex County
Rappahannock River
Piankatank River
King & Queen County
Gloucester County
Mathews County
James City County
York River
York County
Mobjack Bay
Extent Map
PA
OH
MD
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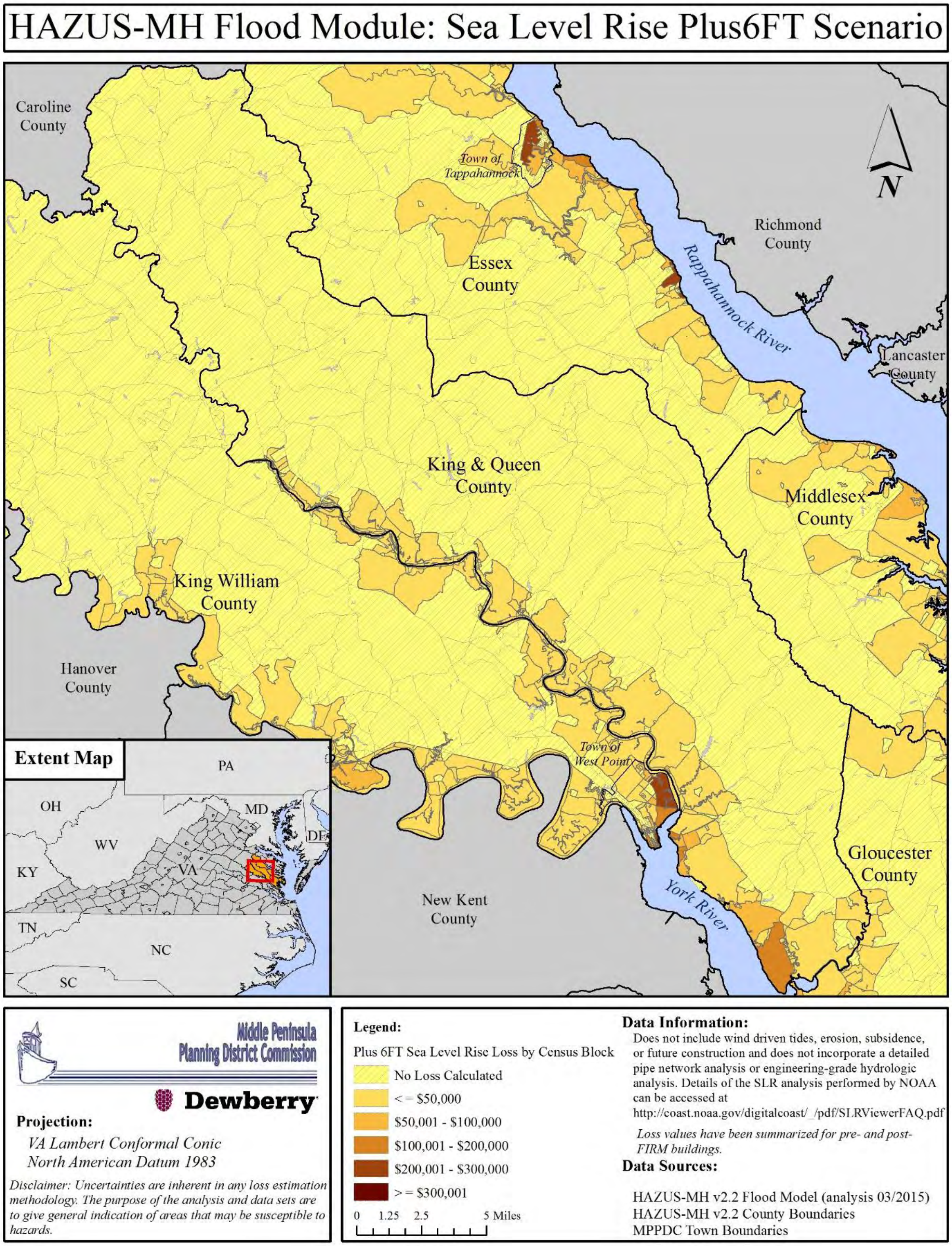
WV
VA
KY
TN
NC
SC
York County
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1.25 2.5 5 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
Caroline County
Town of Tappahannock
Essex County
Richmond County
Rappahannock River
Lancaster County
King & Queen County
Middlesex County
King William County
Hanover County
Town of West Point
Gloucester County
New Kent County
York River
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Extent Map
PA
OH
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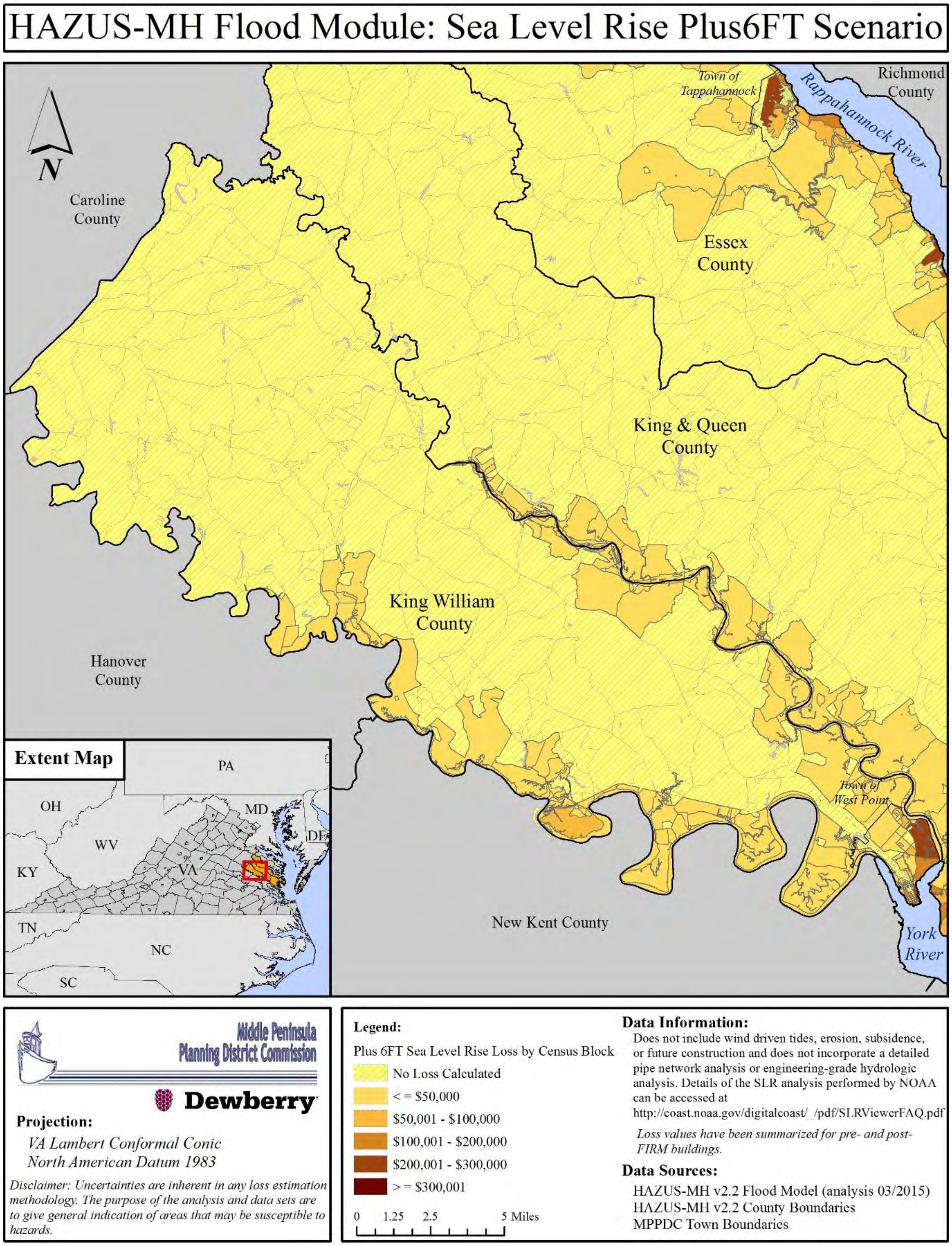
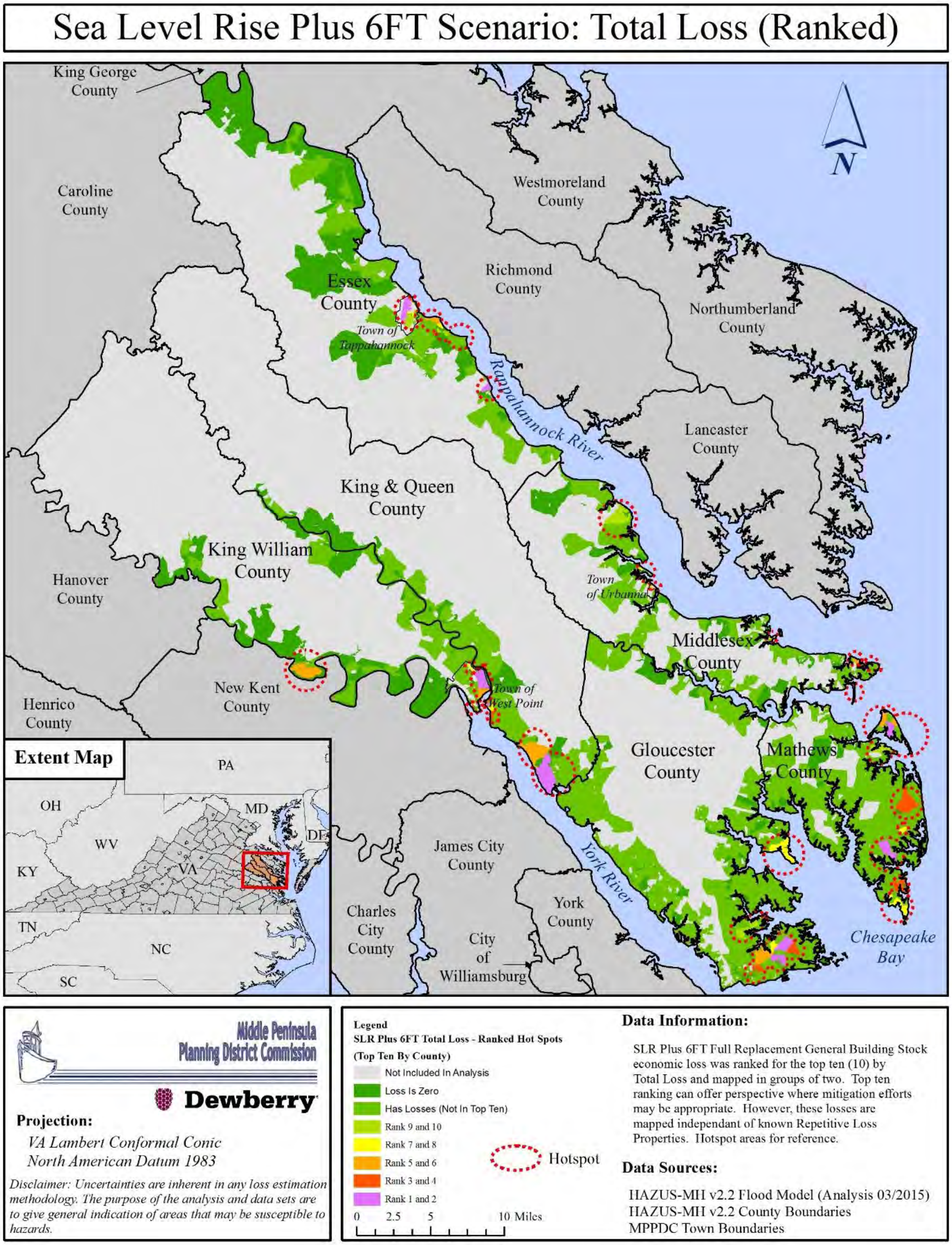
WV
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1.25 2.5 5 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


HAZUS-MH Flood Module: Sea Level Rise Plus6FT Scenario
N
Caroline County
Essex County
King & Queen County
King William County
Hanover County
New Kent County
Richmond County
Town of Tappahannock
Rappahannock River
Town of West Point
York River
Extent Map
PA
OH
MD
DE
WV
KY
VA
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend:
Plus 6FT Sea Level Rise Loss by Census Block
No Loss Calculated
< = $50,000
$50,001 - $100,000
$100,001 - $200,000
$200,001 - $300,000
> = $300,001
0 1.25 2.5 5 Miles
Data Information:
Does not include wind driven tides, erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at
http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf
Loss values have been summarized for pre- and post-FIRM buildings.
Data Sources:
HAZUS-MH v2.2 Flood Model (analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries



Sea Level Rise Plus 6FT Scenario: Total Loss (Ranked)
King George County
Caroline County
Westmoreland County
Richmond County
Essex County
Town of Tappahannock
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Town of West Point
Henrico County
Gloucester County
Mathews County
Extent Map
PA
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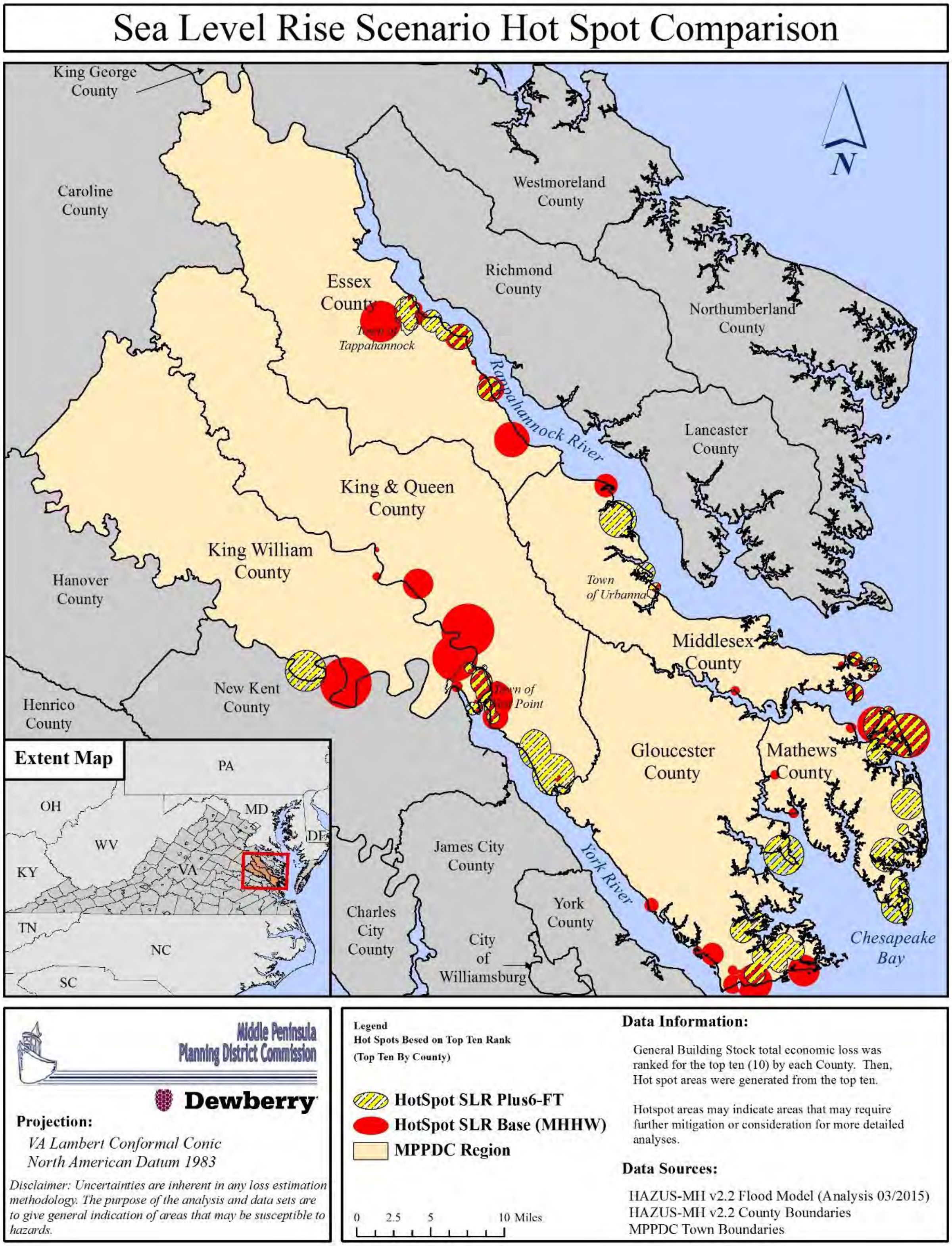
MD
WV
DE
VA
KY
TN
NC
SC
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend
SLR Plus 6FT Total Loss - Ranked Hot Spots
(Top Ten By County)
Not Included In Analysis
Loss Is Zero
Has Losses (Not In Top Ten)
Rank 9 and 10
Rank 7 and 8
Rank 5 and 6
Rank 3 and 4
Rank 1 and 2
Hotspot
0 2.5 5 10 Miles
Data Information:
SLR Plus 6FT Full Replacement General Building Stock economic loss was ranked for the top ten (10) by Total Loss and mapped in groups of two. Top ten ranking can offer perspective where mitigation efforts may be appropriate. However, these losses are mapped independant of known Repetitive Loss Properties. Hotspot areas for reference.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries


Sea Level Rise Scenario Hot Spot Comparison
King George County
Caroline County
Westmoreland County
Essex County
Town of Tappahannock
Richmond County
Northumberland County
Rappahannock River
Lancaster County
King & Queen County
King William County
Hanover County
Town of Urbanna
Middlesex County
New Kent County
Henrico County
Town of West Point
Gloucester County
Mathews County
James City County
York River
York County
Charles City County
City of Williamsburg
Chesapeake Bay
N
Extent Map
PA
OH
MD
WV
DE
VA
KY
TN
NC
SC
Middle Peninsula Planning District Commission
Dewberry
Projection:
VA Lambert Conformal Conic
North American Datum 1983
Disclaimer: Uncertainties are inherent in any loss estimation methodology. The purpose of the analysis and data sets are to give general indication of areas that may be susceptible to hazards.
Legend
Hot Spots Besed on Top Ten Rank
(Top Ten By County)
HotSpot SLR Plus6-FT
HotSpot SLR Base (MHHW)
MPPDC Region
0 2.5 5 10 Miles
Data Information:
General Building Stock total economic loss was ranked for the top ten (10) by each County. Then, Hot spot areas were generated from the top ten.
Hotspot areas may indicate areas that may require further mitigation or consideration for more detailed analyses.
Data Sources:
HAZUS-MH v2.2 Flood Model (Analysis 03/2015)
HAZUS-MH v2.2 County Boundaries
MPPDC Town Boundaries

Sea Level Rise Scenario Comparison Tables:

Table XX. Hazus loss for both Pre- and Post-FIRM – Sea Level Rise Base (MHHW) and Plus 6-Feet.

Area	Scenario [A]	Total Loss	Building Loss	Contents Loss	Business [B] Disruption
MPPDC Region	SLR_Base	$10,185	$6,010	$4,165	$11
MPPDC Region	SLR_Plus6	$283,524	$156,719	$124,964	$2,660
Essex County	SLR_Base	$722	$391	$331	$1
Essex County	SLR_Plus6	$15,866	$8,202	$7,511	$178
Gloucester County	SLR_Base	$2,760	$1,638	$1,120	$1,122
Gloucester County	SLR_Plus6	$116,625	$63,431	$52,381	$53,751
King and Queen County	SLR_Base	$254	$150	$97	$7
King and Queen County	SLR_Plus6	$6,622	$3,999	$2,561	$62
King William County	SLR_Base	$938	$532	$406	$0
King William County	SLR_Plus6	$18,289	$8,561	$9,603	$208
Mathews County	SLR_Base	$2,496	$1,494	$1,002	$0
Mathews County	SLR_Plus6	$96,918	$55,754	$40,566	$711
Middlesex County	SLR_Base	$3,015	$1,805	$1,209	$1
Middlesex County	SLR_Plus6	$29,204	$16,772	$12,342	$131
		Data in Thousands of Dollars			

Notes:

[A] Scenario does not include wind driven tides nor consider natural processes such as erosion, subsidence, or future construction and does not incorporate a detailed pipe network analysis or engineering-grade hydrologic analysis. Details of the SLR analysis performed by NOAA can be accessed at http://coast.noaa.gov/digitalcoast/_/pdf/SLRViewerFAQ.pdf

[B] Business Disruption = Inventory Loss + Relocation Cost + Income Loss + Rental Income Loss + Wage Loss + Direct Output Loss

Potential Mitigation Actions:

The potential mitigation actions noted are those that are Hazus-specific and would benefit refinement of Hazus analyses.

- ☐ Perform Hazus analyses based on the same data resources used to develop the inundation areas mapped in the report submitted to the Virginia General Assembly in January 2013 titled – RECURRENT FLOODING STUDY FOR TIDEWATER VIRGINIA by the Virginia Institute of Marine Science, Center for Coastal Resources Management at the College of William & Mary. This study appears to include the most widely accepted Sea Level Rise plus Storm Surge Scenario facing coastal Virginia. It would therefore be appropriate to consider 1.) The creation of depth grids from the study data and then 2.) Hazus Risk Assessment. It would also be beneficial to incorporate elements of the design storm into a combined Hazus Flood and Hurricane Scenario - in this manner benefits of the combined methodology can be realized – which includes methods to guard against over-counting or double-counting losses by simply adding damages from each respective Hazus model.
- ☐ Refine and update data sets for GBS and essential facilities.
    - Improvements in the future should aim to further refine the building stock. Notably, one improvement should include adding any new development that may not have been in the land use/land cover data; e.g., new housing developments, new construction, etc…
    - Perform localized building-level assessments in known areas of loss and or areas subject to likely losses.